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Planetary Defense

• Energy Flux Density • U.S. Fusion Report

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Features

News

Departments

On the Cover: Artist's rendition of a threat to Earth from space. Illustration by Chris Jadatz, cover design by Alan Yue.

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EDITORIAL

The Fight Over Knowledge

by Jason Ross

In the wake of the over $50 billion in damages caused by superstorm Sandy, and the very lengthy reconstruction and rebuilding process, many media outlets and government figures have blamed climate change for this damaging storm. As only one example, Al Gore wrote on October 30th that "Hurricane Sandy is a disturbing sign of things to come. We must heed this warning and act quickly to solve the climate crisis. Dirty energy makes dirty weather." Leaving aside the fact that the inflation-adjusted damage due to Sandy was far surpassed by hurricanes in the first few decades of the last century, we must ask: which advancements in our understanding of the global climate and weather system have made it possible to determine with total certainty that man-made emissions of CO_2, accounting for a portion of one out of every 10,000 molecules in the atmosphere, were the reason that hurricane Sandy struck with the force that it did?

Among all the uncertainties in life and science, such as the inability to reliably forecast the weather more than a week in advance or figure out what we really ought and ought not to eat, it is nothing short of remarkable that such a complicated process as global climate and weather is claimed to be within our ken! The many factors involved in the behavior of Sandy—such as the early mid-west winter storm, and the high pressure zone over the north Atlantic which prevented the storm from moving out to sea—apparently these were caused by carbon dioxide emissions as well? Al Gore's statement about "dirty energy" fits well with self-styled religious groups who blame various natural catastrophes on God's wrath at our national moral turpitude.

Yet, questioning the science underlying the climate change forecasts of such groups as the IPCC, leads to being branded a heretic, a "climate denier" (the resemblance to "Holocaust denier" is not accidental), and being compared to those who continue to insist that the Earth is flat. "The science is settled," we are told; but, when is science ever settled?[1]

Now let's look at another field of science, where the prevailing official view is that knowledge is not possible: quantum mechanics. In the field of climate science, we are told, *ex cathedra*, that the science is settled on what causes changes in climate, while in the field of quantum mechanics, we are told that our standard idea of causality does not exist.

After Max Planck's hypothesis of the emission and absorption of heat energy in discrete "quanta," Einstein demonstrated, in his work on the

1. The practice of science is political. The multi-trillion dollar pricetag of the proposed policy changes occasioned by climate researchers is obviously a political matter, as are the billions of dollars allocated every year for grants and studies. See, for example, Steve Goreham's delightful new book on the world of climate change hysteria: *The Mad, Mad, Mad World of Climatism*, New Lenox Books, 2012.

photoelectric effect, that all radiative energy exists in such quanta. As quantum science progressed, very eerie aspects of the behavior of the physical universe in the very small began to emerge. One behavior of physics at the quantum level reopened the dispute between the wave and particle views of light, considered definitively decided on the side of waves after the interference experiments of Thomas Young at the turn of the 19th century.

With the work of Einstein, the quantization of light was beyond dispute, but how quantized energy units could then act as waves produced quite a bit of trouble. Later experiments, such as that performed at Hitachi in 1989, demonstrated that even individual photons, sent one at a time through a double-slit apparatus apparently interfered with themselves, as though they went through both slits. With Heisenberg's interpretation, as codified in the wake of the Fifth Solvay International Conference of 1927, the accepted view was that the quanta did not have such physical parameters as location or momentum, but had a variety of locations and dispositions they could take, when called upon to do so by a suitable experimental interaction that forced the particle nature of the quantum to the fore. The older view, that particles and waves propagated through space gave way, as a statistical view, which stated that the probability of finding a particle in a certain location was itself propagating, became hegemonic. Probability was reality, and phenomena in the small were considered inherently random in their nature.

In 1964, John Stewart Bell proposed an experiment that he thought would conclusively demonstrate whether it were possible for such particles to have local "hidden variables," as-yet-unknown (or potentially unknowable) characteristics that would determine their later behavior, which only seemed random. Many experimental tests of Bell's hypothesis have been performed (with a few assumptions), generating the apparent result that among two entangled particles, one affected the other in a way that precluded their future behaviors having been pre-determined at the time of the particles' formation.

Some take this to indicate that indeterminateness is essential, and that Einstein's view of causality was wrong – there is no cause in the very small, in the typical sense of cause, meaning predetermination of the future based on present conditions. Yet, this is to put words into Einstein's (and Planck's) mouths. In a discussion printed in Planck's *Where is Science Going*, Einstein expresses himself:

> I believe that events in nature are controlled by a much stricter and closely binding law than we suspect today, when we speak of one event being the cause of another. Our concept here is confined to one happening within one time section. It is dissected from the whole process. Our present rough way of applying the causal principle is quite superficial. We are like a child who judges a poem by its rhyme, and not by its rhythm. Or, we are like juvenile learner at the piano just relating one note to that which immediately precedes or follows. To an extent, this may be very well when one is dealing with simple compositions, but it will not do, for the interpretation of a Bach fugue. Quantum physics has presented us with very complex processes, and to meet them, we must further enlarge and refine our concept of causality.

Planck, similarly, states that:

> Where the discrepancy comes in today, is not between nature and the principle of causality, but rather, between the picture which we have made of nature, and the realities in nature itself. Our picture is not in perfect accord with the observational results, and, as I have pointed out, over and over again, it is the advancing business of science to bring about a finer accord here. I am convinced that the bringing about of that accord must take place, not in the rejection of causality, but in greater enlargement of the formula and a refinement of it, so as to meet modern discoveries.

Surely this refinement must take, as a *sine qua non*, Vernadsky's concepts of the biosphere and noösphere. The quantum experiments described here have all been performed with abiotic experimental apparatus (and not without reason), but the concepts of time required in such biological processes as evolution, and in human thought and art, can serve to dramatically enrich our notions of "causality," and make possible the refinements that the scientists (and musicians!) Planck and Einstein believed to exist.

For example: free will, which undoubtedly exists in the universe, is neither indeterminate, nor random; and national economic policy looks to the future which is to be, when setting current policies. Let us develop our minds in other fields, continuing to expand our presence as an active force of nature, and return to quantum phenomena with a reservoir of refinements to the nature of causality.

ERICE SEMINAR ON 'EARTHQUAKE EARLY WARNING FROM SPACE'

On October 21-24, 2012, the "Ettore Majorana" Foundation and Center for Scientific Culture (EMFCSC) in Erice, Italy, hosted a seminar on "Earthquake Early Warning from Space." Although earthquake forecasting is still an emerging field, the benefits of space-based observation provide great advantages towards its realization. Because the entire planet can be continuously measured from space, large data sets of atmospheric and ionospheric conditions can be gathered and analyzed, helping to identify even weak interactions between the Earth's crust and the upper layers of the atmosphere and the ionosphere, interactions which can be signs of an oncoming seismic event.

The seminar was directed by Roberto Battison (University of Perugia) and Shen Xuhui (China Earthquake Administration), and featured some of the key figures in the international community of researchers in earthquake precursors and earthquake forecasting. The EMFCSC itself, run by scientist Antonino Zichichi, is also known for its series of International Seminars on Nuclear War (and on "Planetary Emergencies"), which included the 1983 conference on "Technological Bases for Peace" where Edward Teller, Lowell Wood, and U.S. President Ronald Reagan (by personal message) made a major intervention for the Strategic Defense Initiative (SDI) at the time.

Research Center for Earth Operative Monitoring

GPS satellites, whose signals may be used to measure ionospheric characteristics to aid in forecasting earthquakes.

В Российский экспертный совет по прогнозу землетрясений и оценке сейсмической опасности

от члена РЭС **Доды Леонида Николаевича**
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А.В. Николаеву

Копия: Начальнику Центра "Антистихия"
МЧС России
В.Р. Болову

Уважаемый Алексей Всеволодович!

Прошу зарегистрировать и дать экспертную оценку следующему сейсмопрогнозу.

1. В Японии до 15 декабря 2012 г. прогнозируется землетрясение с магнитудой М7+. Наиболее вероятные зоны: восточное или западное обрамление Филиппинской плиты в диапазоне широт 22-37° с.ш. (участок Идзу-Бонинского желоба).

Исходные данные для расчета прогноза отправлены Вам по электронной почте 01.12.2012 г.

2. Прогноз разработан в рамках методического и инструментального сопровождения прогноза доктора А.Любушина и тестирования базовых продуктов сейсмопрогнозного мониторинга в Центре "Антистихия" МЧС России.

Л.Дода
03.12.2012

РЭС

Official earthquake forecast registered by the Research Center for Earth Operative Monitoring with the Russian Expert Council on Earthquake Forecasting and Evaluation of Seismic Dangers.

RUSSIAN CENTER ISSUES FIFTH SUCCESSFUL EARTHQUAKE FORECAST

On December 3rd, Russia's Research Center for Earth Operative Monitoring issued another successful earthquake forecast. Their release (in Russian) describes the forecast they issued, warning of a magnitude 7.2 (± 0.2) earthquake, in the Japan region, on either December 7th or 14th (± 2 days). The U.S. Geological Survey website confirms that there was indeed a a 7.3 earthquake off the Pacific coast of Japan on December 7th — four days after their warning, and matching their forecast. According to their release, this marks the fifth successful forecast of the Center, which is focusing on large earthquakes in the Japan/Kamchatka Pacific region for a trial run of their earthquake forecasting program. The initial successes of the program, as well as their forecasting methods and the parameters they monitored, were elaborated by representatives of the center in two presentations at the September 2012 IGMASS conference, "Space and Global Security of Humanity," held in Yevpatoria, Ukraine, as discussed more fully in this issue, in the article on page 26.

BRAZILIAN SCIENTISTS ARE PLANNING A MISSION TO AN ASTEROID

"Going Where No One Has Gone Before," is the cover story on the November 2012 issue of the magazine *Ciencia Hoje*, published by the Brazilian Society for the Advancement of Science, which describes the proposed "Aster Project," to travel to and land on the largest of a triple-body asteroid, named 2001-SN263. The mission is being designed by three Brazilian and one Russian scientist, with a proposed launch date in 2017. Brazil's National Space Research Institute, and Russia's premier Institute of Space Research, are the responsible institutions for the mission, with the spacecraft to be provided by Russia, and an ion propulsion system and scientific instruments to be provided by Brazil. It would be Brazil's first mission in to deep space.

As the magazine article relates, "If all goes according to plan, this daring deed will secure Brazil a place in the history of aerospace engineering and science. Few nations, until now, have carried out anything like it." Learning as much as possible, as quickly as possible, about these wanderers in the Earth's neighborhood, is urgently necessary, to be able to protect our planet from any possible collisions.

Brazil has had an active space applications program for many years, most notably as a leader in Ibero-America in Earth remote sensing technology. The nation plans to complete the reconstruction of the near-equatorial Alcantara launch facility, to be able to build and launch its own spacecraft in the future.

MINISTERS MEET IN DOHA TO, ONCE AGAIN, SQUEEZE MOONBEAMS FROM CUCUMBERS

From November 26 through December 8, leaders of almost every nation on the planet assembled in Doha, Qatar for the 2012 UN Climate Change Conference. The mission of the subdued meeting was to secure legally binding agreements by all nations to limit their carbon dioxide emissions, with the purported goal of preventing the Earth from heating by more than 2 degrees Celsius over the next few decades, while ignoring the fact that carbon emissions may not even significantly affect global temperature, and that significant research into other areas of climate science is routinely rejected out of hand by the Intergovernmental Panel on Climate Change.

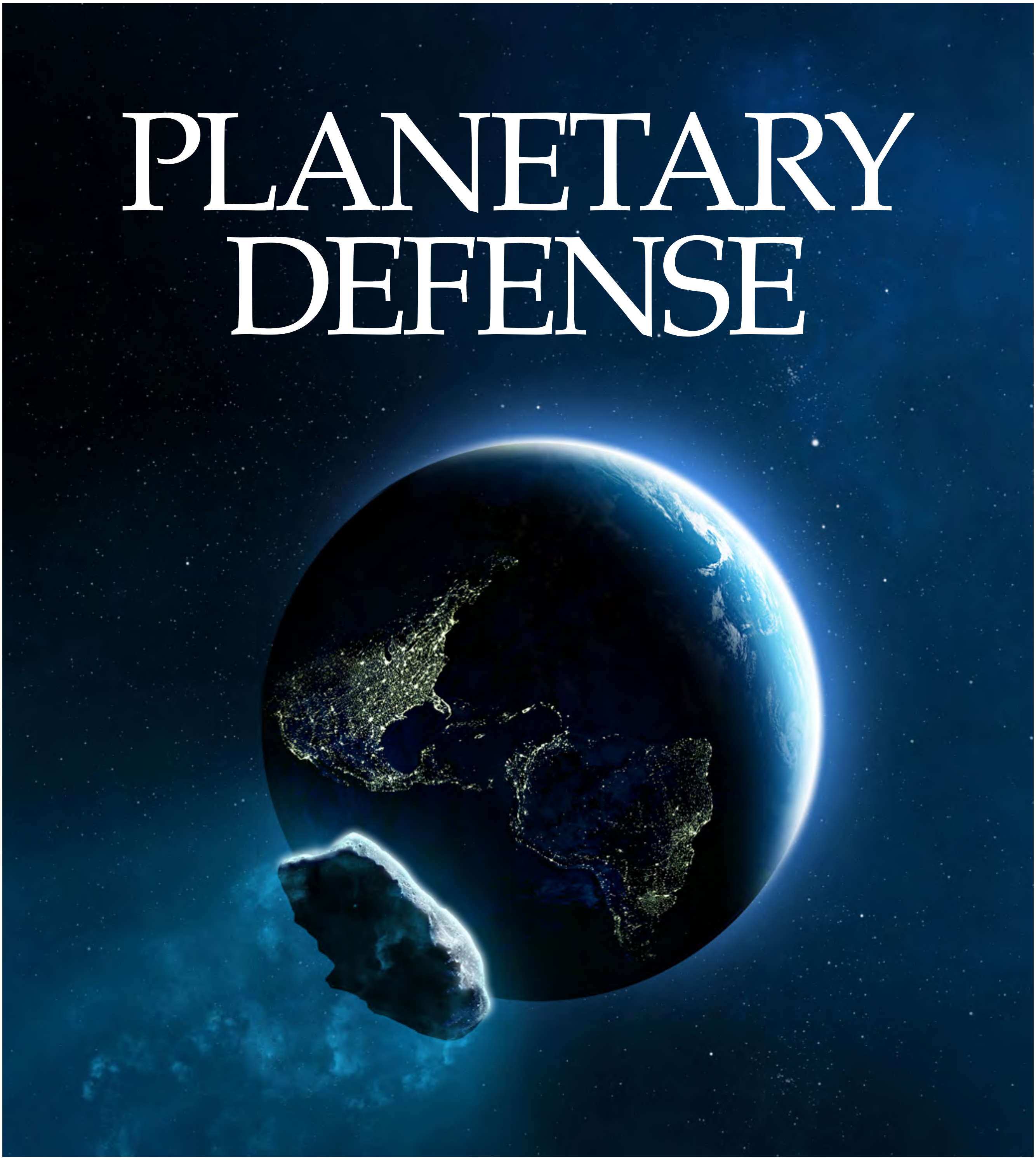
One goal of the conference, to replace the expiring Kyoto Protocol, failed, as only 37 of the 195 parties to the UN Framework Convention on Climate Change supported the proposed new treaty, with the notable lack of support from the US, Russia, China, India, Japan, Canada, and Brazil. All told, the remaining backers of the initiative account for only about 15% of emissions, and the treaty as it stands has no enforceable emissions limits anyway. About $100 billion in future aid was planned for developing nations for "adaptation and mitigation" of climate change.

A dose of reality was finally presented near the end of the conference by climate realist Lord Monckton, who posed as a Burmese delegate and took the microphone for a short period to explain that there has been absolutely no warming for over 16 years, even though carbon dioxide has increased, and that attempting to limit those emissions would cost more than possible remediation later. Instead, he insisted, we should review the science, to make sure we are not simply being swindled into destroying our industries. Monckton's intervention led to his ejection from the country, but he reported that he was happy to have had a chance to speak the truth. Official earthquake forecast registered by the Research Center for Earth Operative Monitoring with the Russian Expert Council on Earthquake Forecasting and Evaluation of Seismic Dangers.

EIRNS/James Rea

Christopher Monckton interviewing greens at a climate conference in Berlin in 2009.

PLANETARY DEFENSE



Introduction

By Jason Ross

This double issue of *21st Century* has a large set of feature articles on the theme of planetary defense and mankind's place in the Solar System and the universe. The treatment of this broad-ranging subject here encompasses everything from detecting precursors to extreme weather, volcanoes, tsunamis, and earthquakes (see also our Winter 2011-2012 issue), to detecting and deflecting incoming asteroids and comets, to the required social outlook to make these missions a reality, to developing the nuclear technologies of fission and fusion propulsion required for efficient access to the Solar System and increased control over heavenly bodies.

Leading our coverage of this topic is an article on the International Global Monitoring Aerospace System (IGMASS) concept, "Toward Collaboration in the Defense of Mankind." This article reports on the proceedings of a fall conference held in Yevpatoria, Ukraine, "Space and the Global Security of Humanity." Discussions at the conference covered the main topics in this feature report as a whole: a global organization for integrating various monitoring systems, located both on the ground and in space, to provide a unified real-time capability to monitor the planet and its environs to forecast a broad range of potential threats to life on Earth. Seismic forecasting, new techniques for observation, rocket design, and political and scientific structures for data sharing were among the topics.

A three-part development of the specific features of planetary defense follows. The first addresses the terrain: some half-million near-Earth objects (NEOs) are estimated to exist, of various sizes, ranging from those which would destroy an entire metropolitan area, to those large enough to eliminate all human life on the planet. Among these hundreds of thousands of bodies, a scant 10,000 have been discovered as this issue goes to press. After a survey of the estimated NEO population and a review of various studies of the effects their impacts on Earth would generate, the topic of observation and detection is treated in the second article. As recent cases of asteroids whose discovery preceded their near-Earth flybys by only a few months attest,[1] our ability to detect such bodies leaves much to be desired. Proposals for additional observatories, including the benefit of observing from the orbit of Venus, are discussed.

The third article concludes with a brief summary of the methods that could be used to stop future impacts from occurring, either by deflecting or destroying a threatening object. Existing options, limited by current technological constraints, are discussed, but a unique emphasis is placed on investigating the areas of scientific and technological advancement which will fundamentally improve our ability to defend the Earth from these threats.

Several interviews provide insights from the research and policy-making communities. Professor Bong Wie (Iowa State University) and Brent Barbee (NASA Goddard Space Flight Center) discuss their proposals for high-speed interceptors with thermonuclear explosives used to disrupt and shatter an incoming NEO. Roscosmos chief Vladimir Popovkin speaks on government initiatives for global planetary defense, and Professor Claudio Maccone, Technical Director of Scientific Space Exploration of the International Academy of Astronautics, presents an overview of the capabilities required to defend the Earth, and steps required to bring those capabilities online.

The Extraterrestrial Imperative

We are then treated to an article on Krafft Ehricke and his concept of the "Extraterrestrial Imperative." Ehricke proposed that space exploration is not simply a set of missions, but the fulfillment of an imperative, which is guided by man's "power of reason" and the "wisdom of the moral law within himself." Space, to Krafft Ehricke, is not a place, but a scientific and cultural challenge which will determine mankind's future. His vision encompassed the extension of mankind's use of near-Earth space, all the way to how our species will continue to grow and evolve perhaps three billion years from now, when the Sun no longer allows the Earth to serve as an abode for life.

Energy Flux Density

A variety of factors serve to measure our scientific capabilities with respect to the challenges of transportation and power for action in space, but the most all-encompassing is that of energy-flux density. Taking a longer historical-economic perspective, it is shown that the development of successively higher forms of power becomes one of the most significant factors in expanding mankind's reach into the universe. This currently presents mankind with the imperative to develop fission and fusion transportation and power systems in space, with an eye towards the great potential of matter-antimatter reactions.

Again, several interviews serve to fill out this concept. Dr. Stanley Borowski discusses U.S. plans for follow-up design studies on fission rockets. Professor John Slough discusses his design for a fusion-powered rocket, which would make the trip to Mars faster, safer, and easier. Academician Anatoly S. Koroteyev, General Director of Russia's Keldysh Research Center, responds to questions on the status of Russia's Nuclear Power Propulsion System, intended to develop the first ever nuclear-electric space propulsion system by 2018.

I hope you will enjoy the exciting contents of this package, and use it to sharpen your advocacy efforts!

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1. Asteroid 2012 XE54 is a case in point. It passed halfway between the Earth and the Moon on December 11th, having been discovered only two days earlier! Its estimated diameter of 25-50 meters puts it in a similar size range to that hypothesized to have caused the 1908 Tunguska event.

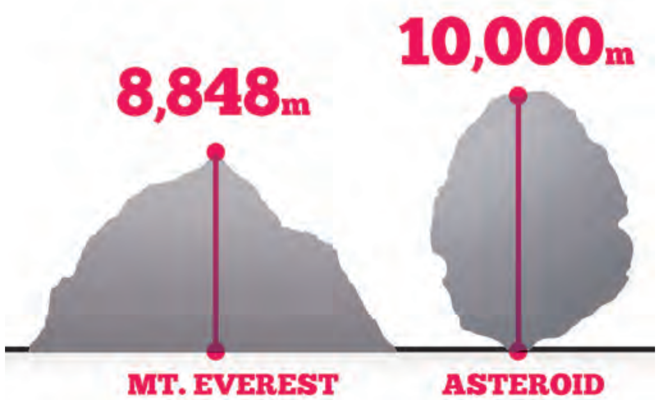
PLANETARY DEFENSE

Threat Assessments

It is difficult to gain a visceral sense of the immensity of energy involved in an asteroid or comet impact on Earth. Although asteroids and comets can range anywhere from meters to many kilometers in diameter[1] (imagine Mt. Everest falling from the sky!), the actual effect of an impact is greatly enhanced by the enormous speeds involved. The total kinetic energy released in such a collision is the product of the mass of the impactor multiplied by the square of the velocity, and the impact speeds range from 10 to 70 km/second, or 20,000 to 150,000 miles per hour![2]

For example, take two notable cases: 1) the impact of an extremely large object, ~10 km, creating the 180 km diameter Chicxulub crater in the Yucatán Peninsula in Mexico, formed around 65 million years ago, which may have helped put an end to the dinosaurs; and 2) the Tunguska event in Siberia, Russia, in 1908, which, though believed to have been caused by a much smaller object, only about 30-50 meters across, resulted in local devasta-

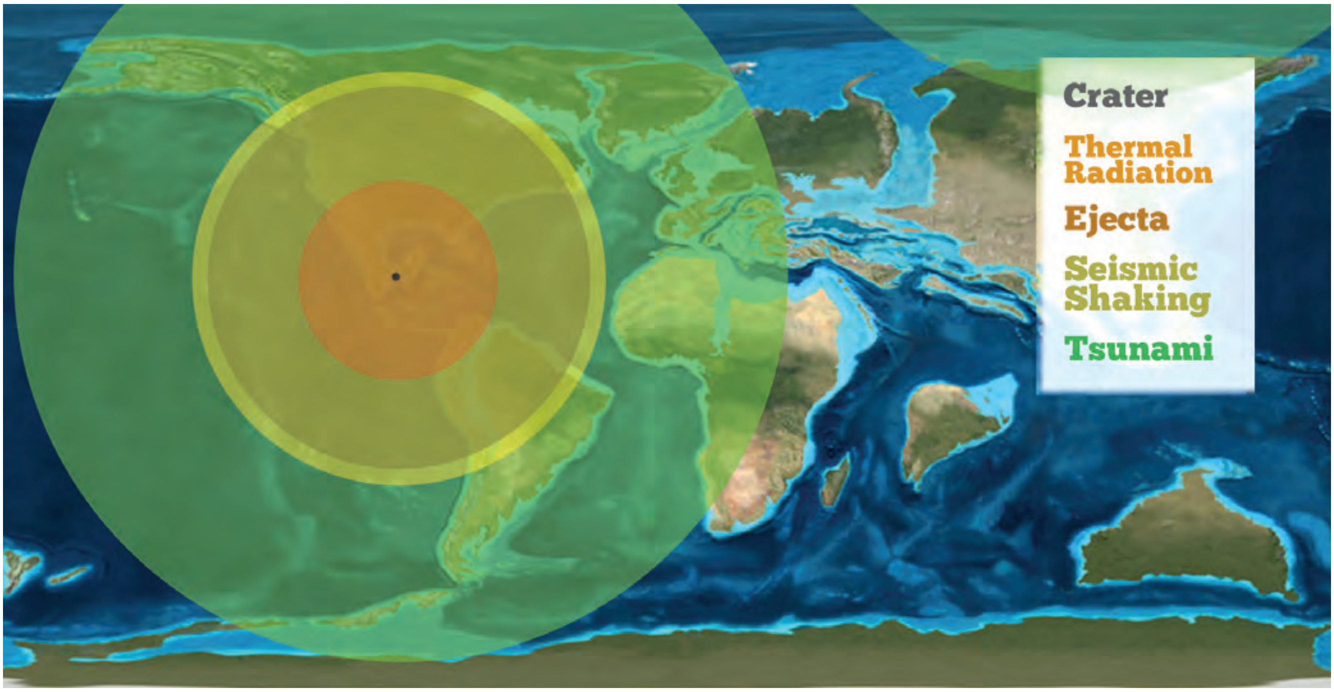
Meteor Crater, Arizona. Credit: Shane Torgerson



1. All sizes of comets or asteroids will be given in the length of the diameter of the object, unless otherwise noted. E.g., a “1 km asteroid” refers to an asteroid with a diameter of 1 km across.

2. For comparison, a typical passenger jet travels at around 500-600 mph (~250 m/s); the speed of sound (at sea-level) is about 770 mph (343 m/s); and the fastest jet ever flown (unmanned) was NASA’s X-43A scramjet, which reached mach 9.8, which is 7,500 mph or 3.1 km/s.

This article is adapted from a 2012 LaRouchePAC pamphlet.



impact effect circles copied from analysis of the "Earth Impact Effects Program," Copyright 2010, G.S. Collins Robert Marcus, and H.J. Melosh, Imperial College London, http://impact.ese.ic.ac.uk/, Original map by Ron Blakey, NAU Geology

The calculated effects of the asteroid which is associated with the Chicxulub crater, estimated to have hit the Earth 65 million years ago. Shown here, from the center outward, are: 1. the range of thermal radiation; 2. ejected material; 3. seismic shaking; and 4. tsunami range.

tion. These two significant cases will help provide a sense of a range of possible scenarios.

Based on studies of Mexico's Chicxulub crater, it has been estimated that a roughly 10 km object, hurtling at around 20 km/s (~45,000 mph), slammed into the Earth ~65 million years ago. Though the exact details of the effects are left to models and simulations, we can certainly get an idea of the scale of destruction: mega-tsunamis[3] thousands of meters high; an expanding cloud of boiling dust, vapor, and ash; rock and other surface material ejected out of the atmosphere, raining back down over a huge area, redhot from its atmospheric re-entry; and shock waves that trigger volcanic eruptions and earthquakes around the entire globe.

To give a rough sense of scale, the energy released by such an impact is estimated to be in the range of 100 million megatons of TNT, 20,000 times larger than public estimations of the entire global thermonuclear weapons stockpile (see table I). In addition, besides the immediate effects of collision, an impact this large would launch so much dust and debris into the atmosphere that a dust cloud would cover the entire planet, blocking out the Sun for years: the impact winter, only one of many possible long-term, global effects.

Fortunately, the Chicxulub case represents an extreme, and relatively rare threat. Such large impacts, though more destructive, are much less frequent than smaller impacts. As will be expanded shortly, our neighborhood in the Solar System is populated with many asteroids and comets; however, the frequency of impact by these objects, generally, is inversely proportional to their size. Nevertheless, while a big object, in the range of 1 km or larger, can create massive global damage, even a relatively small object, can cause significant damage.

One often-cited example of an impact thought to be caused by a smaller object is the Tunguska event, in which a sudden explosion leveled roughly 80 million trees over an area of 2,150 square kilometers in Siberia, Russia. Though some mystery and debate still surrounds this 1908 case, the most well-supported theory is that the blast was due to a comet or asteroid exploding as it impacted the atmosphere, disintegrating before it could hit the Earth's surface, and generating a massive blast wave.[4]

3. Megatsunami is a term used to describe a tsunami that has wave heights which are much larger than normal tsunamis. They originate from a large scale landslide or collision event, rather than from tectonic activity. A recent example is the 1958 Lituya Bay megatsunami, near Alaska, which resulted in a wave hundreds of meters high, the largest known in modern times.

4. Though the Tunguska event drew and has continued to draw intense interest and study, no unambiguous, single impact crater has been found. For example, there is some evidence that it could have been generated by a massive release and explosion of natural gas from underneath the Siberian crust. In any case, we investigate the

Table I
Impacts, Energy Release, and Effects

Asteroid /Comet Size (Meters)	Energy Released (Megatons TNT)	Effects of Impact or Comparable Events
30	2	Fireball, Shockwave, Minor Damage
50	10	Comparable to Largest Thermonuclear Weapon in Existence
200	600	Destruction on a National Scale
500	10,000	Destruction on a European Scale
1,000	80,000	Global Effects, Many Millions Dead
5,000	10 Million	Global Climate Change, Billions Dead
10,000	80 Million	Complete Extinction of the Human Species

Setting aside any lingering debates on the subject, studies have been conducted to determine what size asteroid or comet could have flattened 80 million trees over a region the size of a major metropolitan area. The results of these studies have shown that an object only 30-50 meters across could have generated such a blast wave.[5]

In order to put the range of threats further into perspective, this table presents a comparison of the levels of energy released from various types of events, both man-made and natural.

Structure and Composition

It is also highly important that we determine the physical composition of the interplanetary bodies. Some of the deeper implications of this will be discussed in the sections on defense options and exploratory missions, but here we must note that not all of these objects are structurally similar. Some are almost solid iron-nickel, some solid rock, while many others are loose piles of smaller objects held together by their gravity (sometimes referred to as flying rubble piles).

The Objects

The next question is, where do these objects come from? Our solar neighborhood is much more populated than you may realize. Here, we concentrate only on two specific classes of objects: near-Earth objects and long-period comets. The classical image of our Solar System, four inner planets, then the asteroid belt, followed by four outer planets, while true, does not present the full picture. As Johannes Kepler indicated, and as Karl Gauss proved, there is a major discontinuity between Mars and Jupiter separating the inner from outer planets, which is the home of the majority of the asteroids in our Solar System. However, in addition to this "main belt" of asteroids, there are other populations of asteroids and comets. Some share Jupiter's orbit. Some dwell in between Saturn and Uranus. Many populate the area of the inner planets, including around Earth.

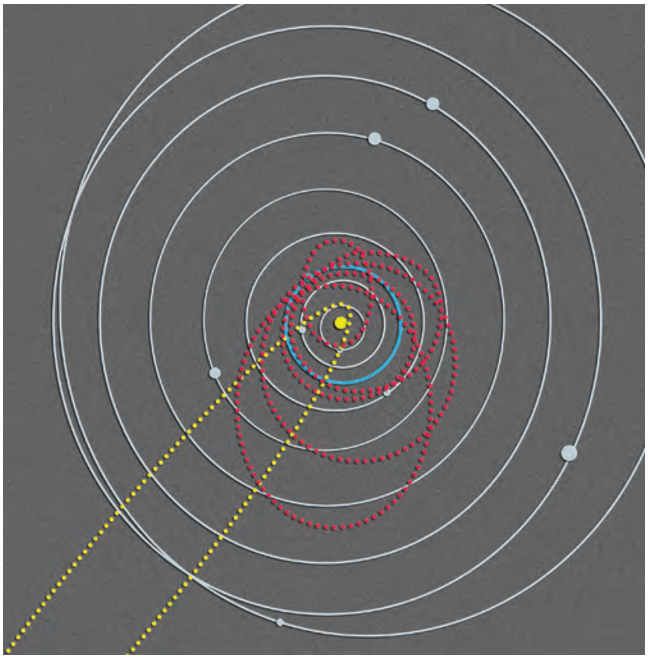
The most successful way to further investigations of the ordering of the entire Solar System will be an elaboration of the methodological approach of Kepler and Gauss, the great minds who discovered the ordering of the Solar System. Instead of starting from pairwise interactions, we must investigate the Solar System as a single, harmonic system, taking a top-down view of the orbital systems and subsystems. Ultimately, applying those methodological considerations will be the key to improving our understanding of the orbits, and determining well into the future what bodies may threaten our planet.

Consider, first, a class of objects known as near-Earth objects (NEOs). This class of potentially threatening objects are mostly asteroids, but include some short-period comets.[6]

asteroid-impact theory in this report.

5. See, *Comet/Asteroid Impacts and Human Society: An Interdisciplinary Approach*, Peter T. Bobrowsky, Hans Rickman, Springer, Feb 21, 2007 - 546 pages.

6. The comets included in the near-Earth objects grouping (sometimes referred to as short-period comets) have dramatically different orbits than the long-period comets mentioned above. Some of these short-period comets can have orbits that are similar to that of asteroids, and constitute a small part of the total near-Earth object popula-



Adapted from a graphic by Jen Christiansen. Source: NASA Jet Propulsion Laboratory
http://www.scientificamerican.com/article.cfm?id=graphic-science#

Orbits of various bodies in our Solar System. The Earth's orbit is in blue, some examples of orbits of near-Earth objects are shown in red, and a long period comet is in yellow.

The defining character of NEOs is that they orbit the Sun *in paths that are either in the same general region as the Earth's orbit, or can even cross the Earth's orbit on a regular basis, raising the possibility of a collision with the Earth at some point in the future*.

Though not all NEOs pose a threat to the Earth, a large number could. Of these, a number have orbits which come within 0.05 AU of the Earth's orbit, and are large enough to cause damage to the Earth. These are referred to as potentially hazardous objects (PHOs).[7] This particular class of objects are of great concern for government agencies and scientific organizations all over the world, who have set out to find and track them, in order to identify potential threats, and to give advanced warning time to prepare defensive actions if needed.

Before going into the current estimations of the NEO population, how to observe and track them, as well as defense options, we must first identify a second class of potentially threatening objects, long period comets (LPCs). The orbits of these comets are completely different from those of NEOs. Whereas NEOs spend their entire life in the inner Solar System, long period comets spend the vast majority of their lifetime out in the farthest depths of the Solar System (often well beyond the orbit of Pluto.) The extreme ellipticity of some of these distant creatures can take them on rapid trips through the interior of the Solar System, and possibly across Earth's orbit.

These create a number of significant problems for defending the Earth. First, the key to planetary defense is early detection. While we have had success in detecting NEOs which populate the inner region of the Solar System, it is basically impossible, with present technology, to see the vast majority of these long period comets when they are farther away. Not only does this dramatically shorten warning times, but, since the majority of these comets take hundreds of thousands of years to complete a single orbit around the Sun (some even take millions of years), we know little to nothing about the nature of the long period comet population. In addition, from what we do know, they are often very large, and can have impact speeds of up to about 70 kilometers per second (over 150,000 mph), significantly greater than asteroids.[8]

Currently, compared to NEOs, we see far fewer long period comets passing our region of the Solar System, so it is expected that their impacts with the Earth are much less frequent. However, they have hit the Earth in the past, and if one were on a future impact trajectory, its great speed, large mass, and undetectability until close to the Earth would make it a particularly dangerous global threat. These are the type of bodies that could eliminate all human civilization with one impact.

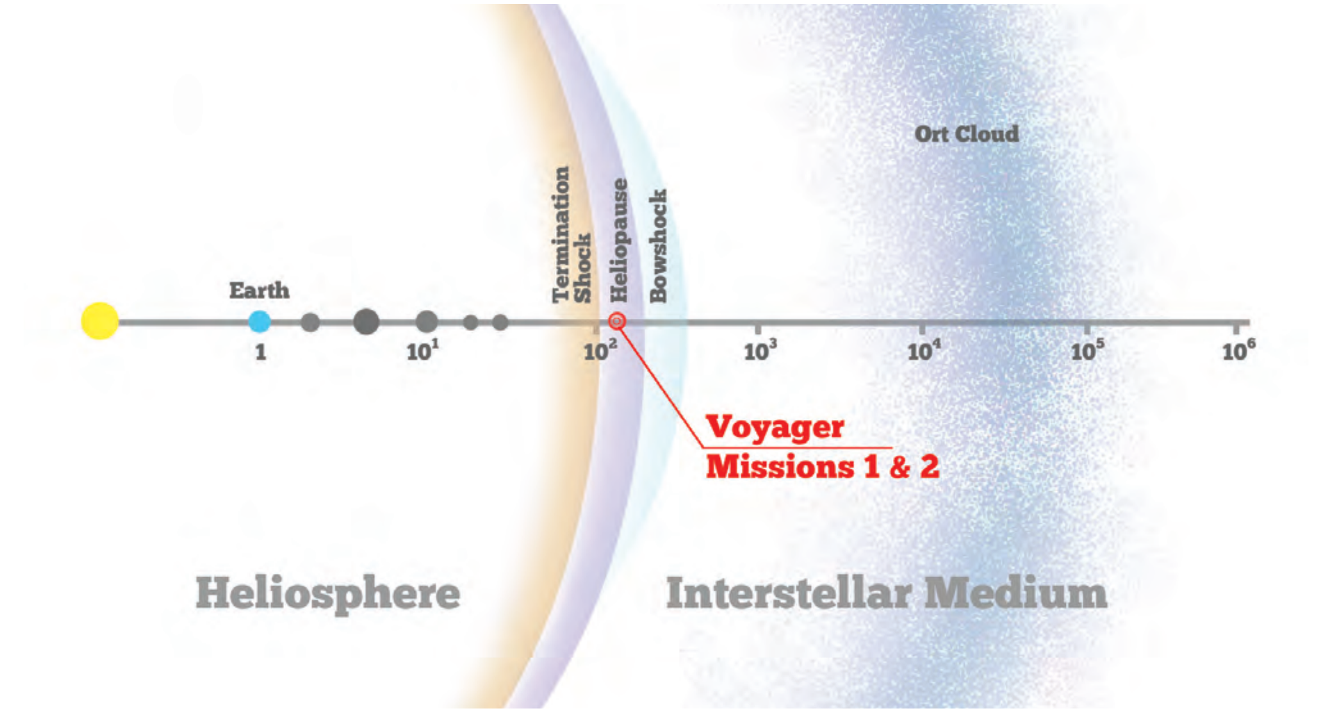
There is also reason to believe that the population of long period comets which pass into the interior of the Solar System is not completely random. The current hypothesis is that these long period comets may originate from an extremely distant spherical structure surrounding the Sun, at the farthest reaches of the Solar System, known as the Oort cloud. Presently we do not have the observational capability to see comets that far away (a 10 km object at 10,000 times the distance of the Earth from the Sun is hard to spot), but it is thought that the number of large comets (larger than 1 km) in the Oort cloud is in the range of trillions.

Since they extend so far beyond the Solar System, these comets become sensitive to galactic factors. Other stars coming close to our Solar System can perturb the Oort cloud, changing the orbits of potentially millions of comets. Beside individual influences, at these distances, the gravitational effect of the Sun is less dominant and the

tion.

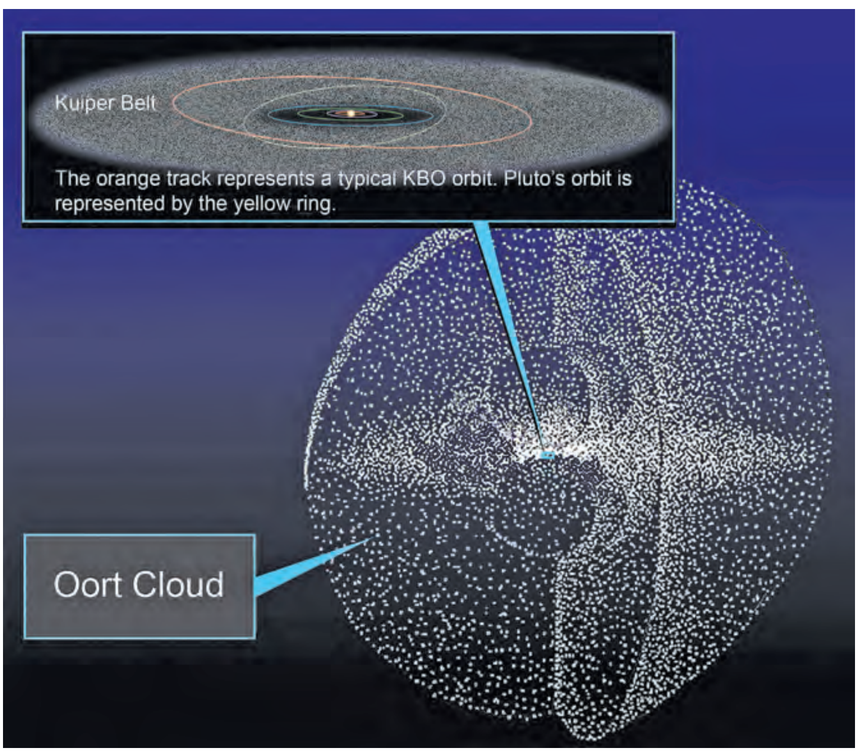
7. AU stands for astronomical unit, the average distance from the Earth to the Sun. It is used as a standard measure of distance in the Solar System. Also don't be fooled by the image above, as bodies in the Solar System orbit within a thin volume, not a flat plane. Two orbits that may look like they intersect, when drawn on paper, may not, because one could be above the other.

8. Remember that the energy released on impact goes up with the square of the speed. To give one example, the 70 km/second impact speed of a comet, going three and a half times faster than the 20 km/second impact speed of an asteroid of the same size, would deliver over 12 times more energy.



Adapted from Donald Yeoman's Illustration, JPL, NASA

An artist's mapping of the Solar System on a logarithmic scale. The planets are various sized dots on the line, the edge of the Sun's magnetic field is indicated as the heliopause, and the hypothesized location of the Oort cloud is shown at its farther distance.



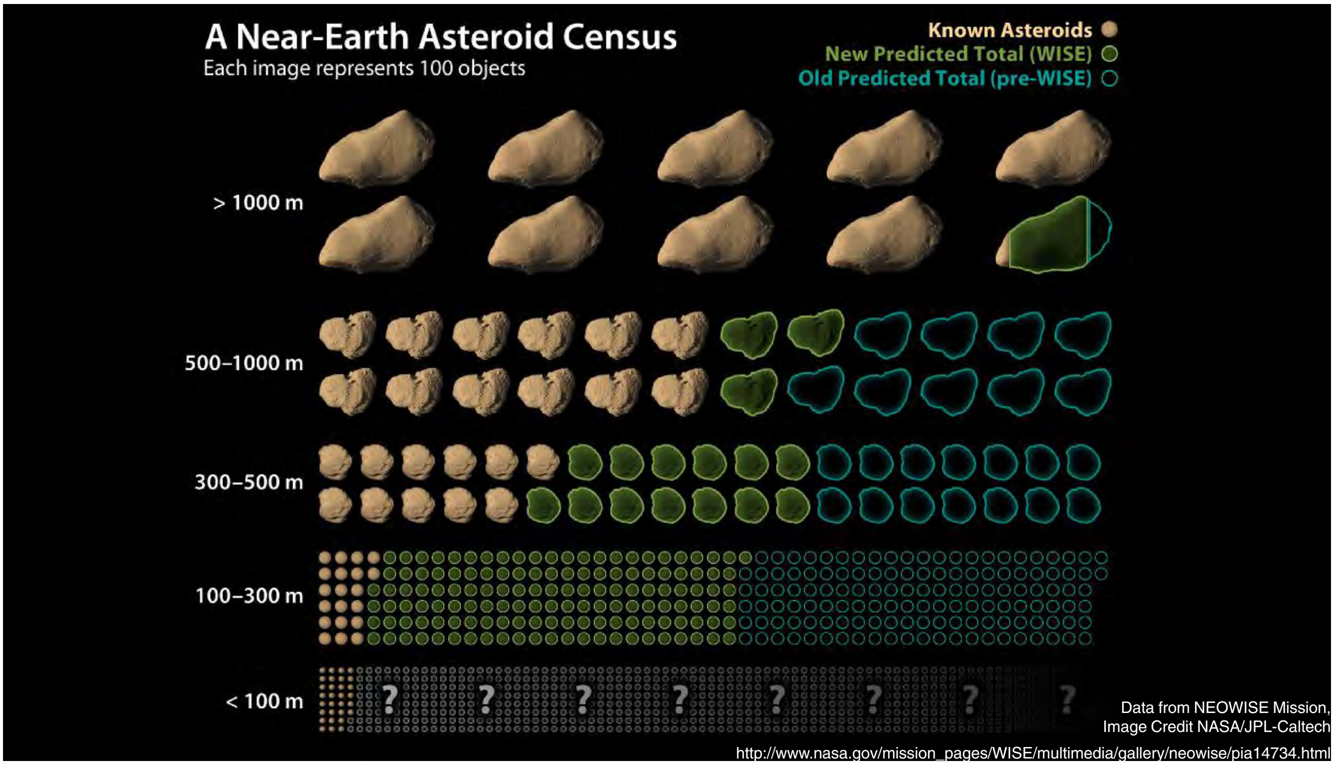
Original by R. Mewaldt & P. Liewer, JPL, NASA

Artist's depiction of the hypothesized Oort cloud distribution of cometary bodies populating the farthest reaches of the Solar System.

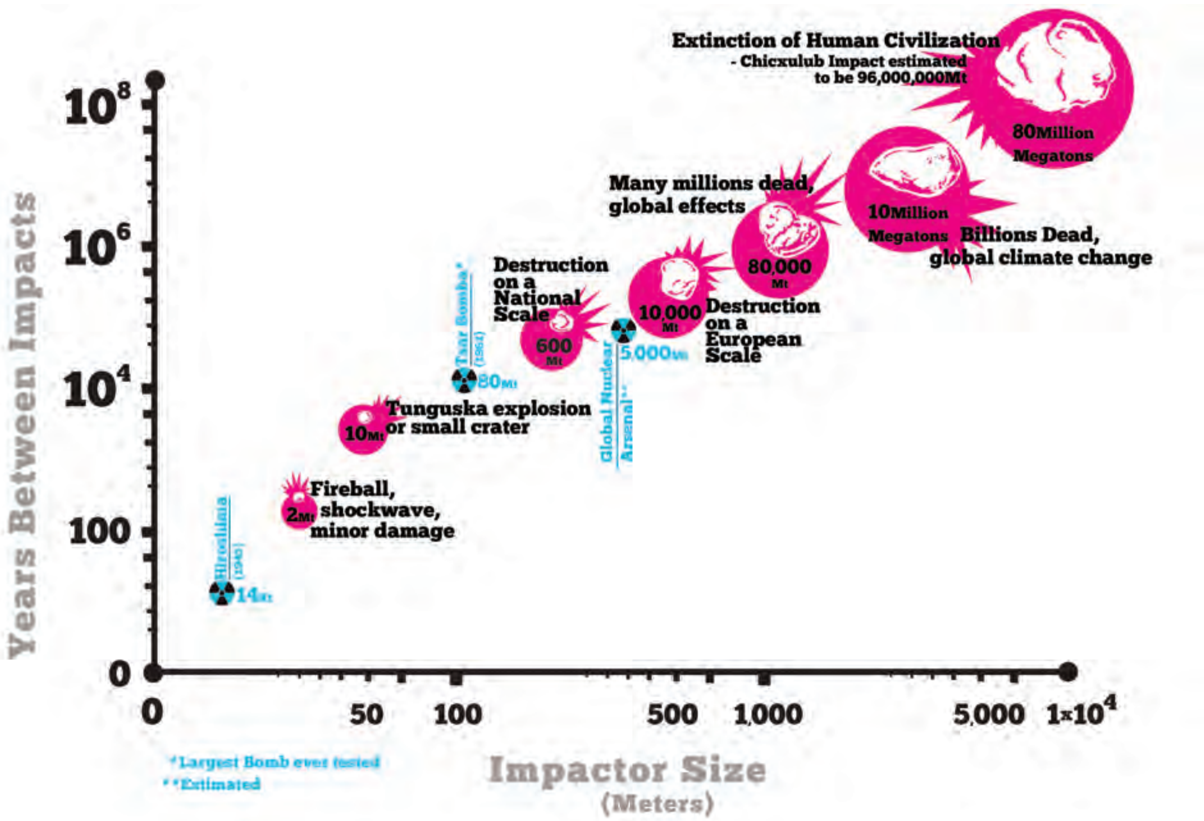
general gravitational field of the galaxy begins to have an influence—an effect which varies as the galaxy evolves, and as our Solar System travels through it.

Even though our current scope of understanding regards these galactic processes as having slow, long-term effects, they are the type of considerations that mankind must begin to take into account at this stage. First and foremost, there is still little in the way of solid knowledge about these outer regions of the Solar System, and much less known about our Solar System's relationship with our galaxy and how those galactic changes affect us here on Earth. There are many theories and models, but as we are reminded by the fact that recent readings from the two 35-year old Voyager spacecraft continue to surprise the scientific community, we cannot assume that we understand these neighboring regions, or the solar-galactic interactions, until we go out and investigate.

If there is some doubt as to why mankind has an imperative to understand



This chart shows the percentage found (tan) of the estimated total population (green) of near-Earth asteroids of various size categories.



Adapted from: *Catastrophic Events Caused by Cosmic Objects*; 2008, Springer; Chapter 2, "Size-frequency distribution of asteroids and impact craters: estimates of impact rate."

Table II

Size Range	Estimated Population	Number Found	Percentage Found
1 km+	900	850	94%
300m to 1km	4,800	2,400	50%
100 to 300m	21,000	2,100	10%
30 to 100m	~500,000	~1,950	0.4%

our solar and galactic environment, let long period comets draw for us a larger neighborhood.

While our current capability to defend against the threat of long-period comets is limited, the state of our knowledge of near-Earth objects is less uncertain.

Population and Impact Frequency Estimations

Due to their close orbits, near-Earth objects can be observed and tracked with Earth-based and space-based telescopes. Following on a few decades of observation programs, astronomers have developed a significant catalogue of known near-Earth objects. Depending on how well and for how long each individual NEO is observed, computer models can be used to extrapolate each NEO's orbit and trajectory, years or decades into the future.[9] These multi-decade extrapolations are crucial, since the key to defense against a potentially threatening asteroid is having as much advanced warning time as possible.

Presently, we are far from having discovered and tracked every NEO, and that must be done. The limited population that has been characterized by current surveys has been used to extrapolate statistical estimations of the expected total NEO populations. For example, in September 2011, a NASA-led team published updated estimations of NEO populations based on the data obtained from the Wide-field Infrared Survey Explorer (WISE) space telescope.

Since then, various estimates continue to be refined as increasing amounts of data from Earth-based telescopic surveys are received. One of the more recent available estimates was released in April of 2012, and presented by the head of NASA's NEO program, Lindley Johnson, at a May 2012 Workshop on Potentially Hazardous Asteroids.[10]

As is clear in table 2, we have been rather successful in identifying most of the larger NEOs. Of the discovered populations, some fit the specific category of potentially hazardous objects, meaning that their orbits come close to or even directly cross the Earth's orbit. Currently, 152 of the discovered 850 near-Earth asteroids larger than 1 km are classified as PHOs, although none are expected to collide with Earth over the coming century. This is important, since 1 km is a rough division line between objects which would create truly global effects if they struck the Earth, and objects whose impact would produce a local or regional effect.

Still, this leaves the vast majority of medium and small-sized objects undiscovered: ~80% (over 21,000) of the middle-sized NEOs, ranging from 100 to 1000 meters; and ~99.5% of smaller NEOs, 30-100 meters (recall that the Tunguska-sized event is associated with objects in the range of 30-50 meters).

Any of these undiscovered objects could already be on a short-term collision course with Earth, unbeknownst to us. Some are guaranteed to be, at some point in the future. We are still essentially flying blind through our populated region of the inner Solar System.

Further analysis has provided estimations of the frequency with which various sized NEOs and comets impact the Earth.[11] As implied by the NEO population estimates referenced above, and as indicated in the graph on the preceding page, there is a direct relationship between the size of the NEO, the population level, and the impact frequency.

These estimations of NEO populations and impact frequencies are still approximations, and should only be taken as temporary reference points, paving the way for more rigorous investigations. We cannot entrust human lives, or potentially human civilization, to betting on statistics which purely extrapolate from past events. They can be utilized in limited applications where useful, but only on the path to obtaining a principled—causal—understanding of the system. This requires both a dramatic expansion of our observational systems and our space-faring capability generally, as well as renewed methodological approaches to understanding the organization of the Solar System, and its relationship with the galaxy. Reliance on statistical extrapolations from the past leaves mankind completely blind to unexpected shifts away from present trends, driven by the development and evolution of the Solar System and galaxy—a process driven by future changes.

9. Obviously, the more observations of an object we have, and the better those observations are, the better the forecast will be. Still there are certain subtle effects which require greater investigation, such as composition, spin rates, and non-gravitational effects, such as an uneven heating/emission action referred to as the Yarkovsky effect. Moreover, there are questions about the methodology of the computer models themselves: they generally rely on only a few dozen large bodies to model the field through which the others pass.

10. http://neo.jpl.nasa.gov/neo/2011_AG5_LN_intro_wksp.pdf, April 17, 2012, Alan B. Chamberin (JPL).

11. For example see, *Catastrophic Events Caused by Cosmic Objects*; 2008, Springer; Chapter 2, "Size-frequency distribution of asteroids and impact craters: estimates of impact rate."

The Mystery of Tunguska

by William Jones

"If you want to start a conversation with anyone in the asteroid business, all you have to say is Tunguska," said Don Yeomans, manager of the Near-Earth Object Office at NASA's Jet Propulsion Laboratory, in June 2008, on the 100th anniversary of the Tungskua event. Nothing has fascinated scientists more than the mysterious explosion that occurred in a desolate area in eastern Siberia on June 30, 1908. Nor has any other event done more to feed the wild speculations about vehicles from outer space or other outlandish theories. The explosion was registered by sensitive barometers as far away as England. The shock wave leveled more than 2,100 square kilometers of the forest. Vegetation over an area of 200 square kilometers was burnt by the flashover. Minutes after the explosion, a magnetic storm began which lasted five hours. And reports came from all over Asia and Europe of a strange sky, covered with high clouds, but with a distinct light that lit up the night for several days.

While the event obviously became a matter of great scientific interest, no serious investigation would be conducted for another 13 years, given the isolated location and the formidable task, in those days, of traveling to such far reaches of Siberia. It wasn't until 1921 that, upon the urging of leading geochemist, Vladimir Vernadsky, an expedition was outfitted under the leadership of Leonid Kulik, the secretary of the Meteoretic Department of the Mineralogical Museum, which was headed by Vernadsky. The initial assumption was that a meteorite had landed in Siberia, and it was Kulik's mission to find remnants of the meteorite. This first mission, however, was not able to reach the exact location of the event, but collected material from an adjacent area. It was not until 1927 that Kulik, again at the urging of Vernadsky, was able to launch a second expedition. While Kulik was able to document the devastation in the area—the burnt trees, many of them bent by the explosion, the forest fire, and several craters that must have resulted from the event—there were no signs of any meteorite. Kulik was crestfallen, and the search for parts of a meteorite became something of an obsession with him until his death in 1942.

Not so Vernadsky. He felt that given the lack of any remnants of a meteorite, the explosion must have been a different type of atmospheric event, perhaps a comet that transited the Earth's atmosphere, with devastating effects, but leaving no solid particles, except remnants of cosmic dust. In 1932, in an article entitled "On the Study of Cosmic Dust," Vernadsky would write: "The attempt by L.A. Kulik to find it [a meteorite] at the location of the fall, which was probably correctly estimated, was unsuccessful. It's possible, as was indicated, that the penetration of the Earth's atmosphere by a mass of cosmic matter did not descend to the Earth's surface, but again escaped into cosmic space, leaving only the remains of matter in the form of minute particles in the atmosphere. But it's also possible that the "Vanavara meteorite" is a new phenomenon in the pages of science—the penetration into the Earth's gravitational field not of a meteorite, but of a gigantic cloud or clouds of cosmic dust, traveling at cosmic speed."

Vernadsky's hypothesis of a comet as the cause of the Tunguska explosion has been confirmed twice over. In a recent expedition to the area in 2010, a Russian team, led by Vladimir Alexeev from the Troitsk Innovation and Nuclear Research Institute (TRINITY), started examining Suslov crater, which was created by the event. Using ground-penetrating radar, they were able to determine that underneath the recent permafrost and a layer of damaged material, was a layer of ice. Comets, or "tailed stars," consist of very unusual ice formed from water, methane and other gases, and dust. In addition, the expedition found matter of non-terrestrial origin in the resin of trees in the epicenter of the explosion. The researchers concluded that the substance was very similar to cosmic dust which is a part of a comet nucleus.

A year earlier, in 2009, a Cornell research team studying the exhaust plume from a NASA Space Shuttle launch, made another discovery, indicating that Tunguska may have been a comet. The exhaust plume of the Shuttle at take-off spews 300 metric tons of water vapor into the Earth's thermosphere. The water particles have been found to travel to the Arctic and Antarctic regions, where, for several days, they form noctilucent clouds, at the very edge of the upper atmosphere. These thin clouds are made up of ice crystals, through which glows a nocturnal light. Such clouds were also observed following Shuttle launches in 1997 and in 2003.

So, too, with the Tunguska event, the icy tail of a comet could also have caused those mysterious noctilucent clouds, which were clearly visible for several days after the explosion, as far away as Great Britain. "It's almost like putting together a 100-year-old mystery," said Michael Kelley, the James A. Friend Family Distinguished Professor of Engineering at Cornell who led the research team. "The evidence is pretty strong that the Earth was hit by a comet in 1908."

PLANETARY DEFENSE
Observation Systems

Fortunately, mankind has not been completely negligent on the issue of tracking potentially threatening near-Earth objects (NEOs) and comets. In the United States, serious recognition of the threat of potential impacts with the Earth started to grow in the 1980s, and by the 1990s the U.S. Congress issued a mandate to NASA, tasking them to find and track 90% of all NEOs larger than 1 kilometer, in order to determine if any pose a threat to the Earth in the future. This mandate led to the development of the "Spaceguard" program, which is a loose alliance of survey programs which receive money from NASA to find and track NEOs.

The past decades of observation under these programs have provided a start to addressing this planetary challenge, but, as is seen from the asteroid population estimates discussed above, we are still far from identifying all the potentially threatening NEOs which populate our immediate neighborhood. Looking to greater challenges, these existing NEO survey programs are not designed to deal with the challenge posed by the second class of rarer, but potentially more threatening objects, long-period comets, which come from the farthest depths of the Solar System, and are, for all practical purposes, impossible to detect at their great distances.

To successfully tackle both of these threats, mankind must rapidly expand its sensory systems based on existing designs, while at the same time developing new technologies to handle threats outside of our current technological capability.

The best possible option is for the United States, Russia, and China to cooperate in a joint science driver program, the beginnings of which have already been put forward by the Russian government in the form of the Strategic Defense of Earth proposal to the United States.

This article is adapted from a 2012 LaRouchePAC pamphlet.

Existing Programs

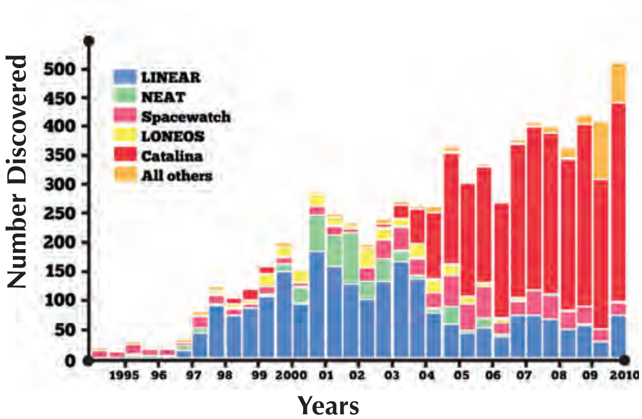
A series of ground-based observation programs have been developed to search for near-Earth objects. The following chart indicates how many near-Earth asteroids have been discovered each year and by which observation programs.

Observations from these and other telescopes are then centralized in the computer systems of the International Astronomical Union's Minor Planet Center (Smithsonian Astrophysical Observatory, Massachusetts). These systems, along with NASA's Jet Propulsion Laboratory (the Horizons Ephemeris Computation Facility) and the Near Earth Object Dynamics Site (NEODyS) at the University of Pisa, Italy, can then approximate the orbits of NEOs, and extrapolate their trajectories decades into the future.

These surveys and orbital extrapolations provide the first line of defense. Detecting a threat decades before it may impact would provide the necessary time to launch a mission to change the threatening object's trajectory.

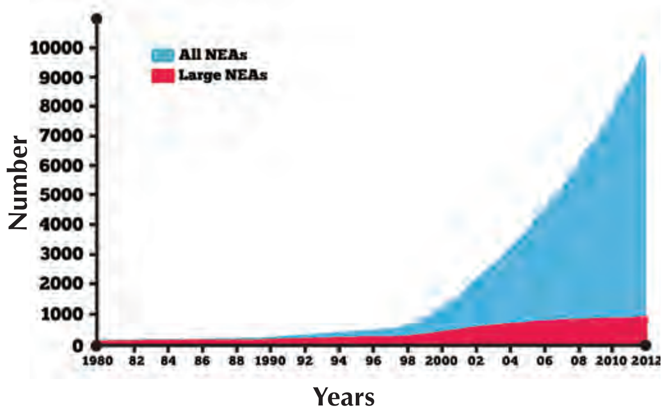
For these reasons, early warning is of the utmost im-

Yearly Discovery of Near-Earth Asteroids by Program



NASA, Data compiled by Alan Chamberlin

Known Near-Earth Asteroids (January 1980-June 2012)



NASA, Data compiled by Alan Chamberlin

portance. However, current computer simulations can not provide absolutely precise determinations of asteroid or comet orbits that far into the future, and instead provide a range of possible trajectories based on various uncertainties. While it is true that more observations lead to more accurate orbits, there are still limiting factors which keep scientists from achieving the accuracy needed. One crucial aspect of this problem is taken up in the interview with Claudio Maccone, on page 46 of this magazine.

In addition to ground-based observatories, the first steps have been made to utilize space-based telescopes to improve our view of the Solar System. This option was demonstrated with NASA's Wide-field Infrared Survey Explorer (WISE), an infrared space telescope which only operated for a short period of time, but opened a completely new window to view our neighboring asteroids and comets. Seeing these objects in the infrared end of the spectrum (which can only be done from space) provides an improved capability to determine their size, and to see small dark objects.

These first steps have been useful, but even with a decent discovery rate by present systems, it will take us decades to begin to come close to identifying the total population of near-Earth objects alone. It is time for nations to take up this challenge in a serious way. Up to the present, these efforts have been limited to a small number of concerned scientists who have demonstrated the existential importance of asteroid and comet defense. Their initial accomplishments could be rapidly expanded by an international mission.

Existing Proposals

In April of 2010, a NASA ad hoc task force was commissioned to advise the relevant agency officials on how best to further efforts to defend our planet from threatened NEOs. A short report was released in October of that year which provided a series of recommendations.[1]

Included in the recommendations is the construction of one or more space-based infrared telescopes dedicated to accelerating the detection and characterization of the NEO population. As discussed above, utilizing the infrared region of the spectrum provides an improved ability to see and identify these bodies. It was recommended that one or more of these infrared space telescopes be placed in orbit around the Sun, but at a distance similar to that of Venus. Because we can only see these objects when looking away from the Sun, this position, being inside the Earth's orbit, provides a better viewing angle to see a larger section of the NEO population.

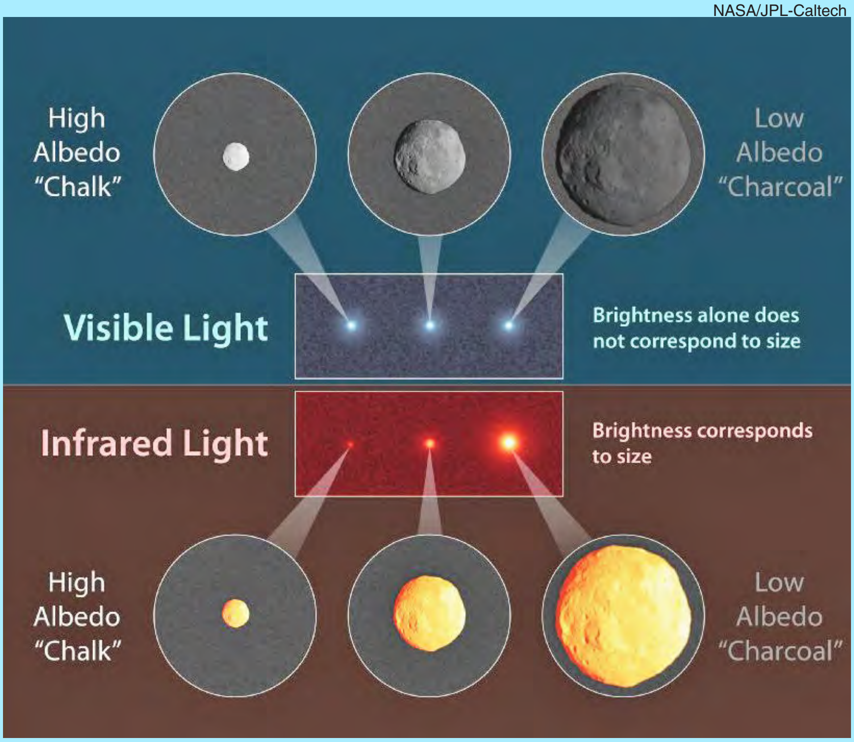
This would be a significant step towards identifying and tracking the NEO population, but unfortunately NASA has not been able to take up this recommendation.[2]

This is a step in the right direction, but we must also consider what it will take to tackle the second class of problems, long-period comets. The 2010 NASA report on planetary defense chose to focus solely on the NEO threat, leaving out the issue of long-period comets, for the following reasons:

1. "Report of the NASA Advisory Council Ad Hoc Task Force on Planetary Defense;" October 2010.

2. Because of the inability of NASA to pursue this, a non-profit organization dedicated to the issue of planetary defense, the B612 Foundation (whose board of directors includes key participants of the 2010 NASA ad hoc report), has recently announced plans to build and launch an infrared telescope of this type supported by purely private funding. The "Sentinel Mission" is planned for launch in either 2017 or 2018.

How to Tell the Size of an Asteroid



This chart illustrates how infrared is used to more accurately determine an asteroid's size. As the top of the chart shows, three asteroids of different sizes can look similar when viewed in visible light. This is because when visible light from the Sun reflects off the surface of the rocks, the more reflective, or shiny, the object is (a feature called albedo), the more light it will reflect. Darker objects reflect little sunlight, so to a telescope from millions of miles away, a large dark asteroid can appear the same as a small, light one. In other words, the brightness of an asteroid viewed in visible light is the result of both its albedo and size.

The bottom half of the chart illustrates what an infrared telescope would see when viewing the same three asteroids. Because infrared detectors sense the heat of an object, which is more directly related to its size, the larger rock appears brighter. In this case, the brightness of the object is not strongly affected by its albedo, or how bright or dark its surface is. When visible and infrared measurements are combined, the albedos of asteroids can be more accurately calculated.

"The population of long-period comets, with orbits originating in the outer Solar System, represents a small part of the total comet threat, and thus an even smaller part of the total impact hazard. Because the tasks of effectively detecting and deflecting objects of this size and velocity are beyond our present technology, the Task Force report does not address long-period comets."

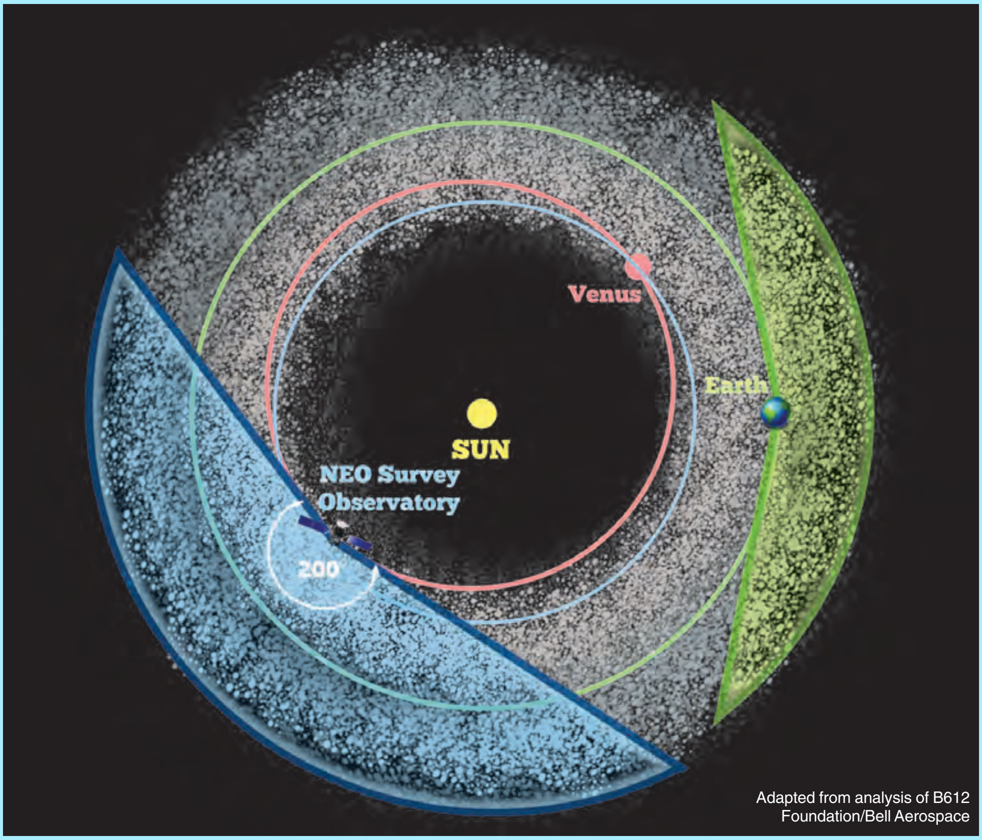
While long-period comets do have a lower frequency of impact, this does not mean that we should ignore the problem.

There have been preliminary investigations into what would be required for adequate detection times for long-period comets, most of which focus on developing space telescopes with much larger apertures to be able to see deeper into space. For example, one analysis discussed using light-weight structures to construct 25, 50, or even 75 meter telescope diameters.[3] This would be a dramatic improvement,[4] and is thought to allow us to look deep enough into space to provide warning times for long-period comets on the order of 6, 11, and 16 years respectively. Given the sizes and speed of many of these objects, even these warning times would be minimal, if not still too short.

These telescope designs are just two key examples of proposals to expand the observational capability in order to meet the demands posed by both NEOs and comets. Much more detailed analyses have been made for these and other systems, and more analyses can be done, but we must begin to move to the construction phase of such systems immediately.

3. "Obtaining long warning times on long-period comets and small asteroids—Extremely large yet extremely lightweight space telescope systems," Ivan Bekey, 2004 Planetary Defense Conference: Protecting Earth from Asteroids; Orange County, CA; Feb. 23-26, 2004.

4. The Hubble space telescope is 2.4 meters across, and the James Webb space telescope will have a diameter of 6.5 meters.



NEO Survey Observatory Placing a space telescope closer to the Sun, for example in an orbit similar to that of Venus, allows for a larger viewing angle to see near-Earth objects.

The Limits of Statistics

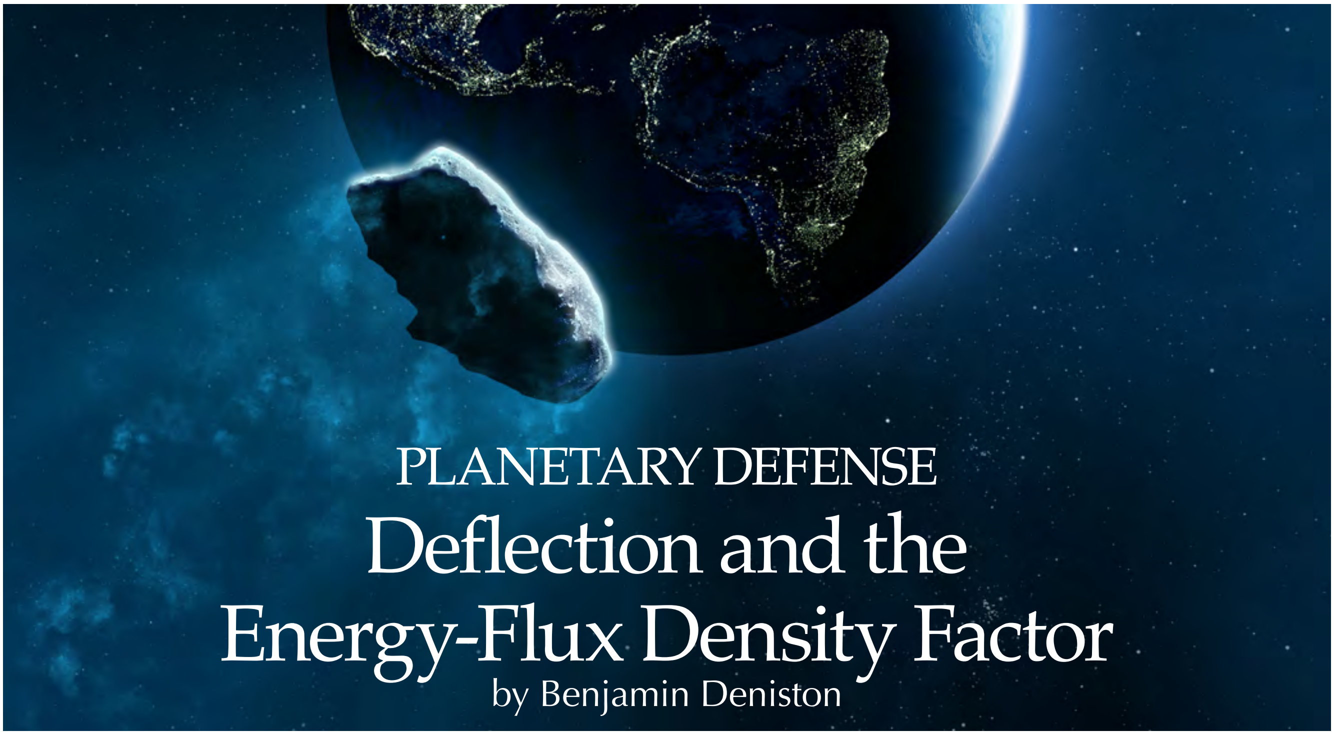
A 30m object impacts the Earth every 200 years, on average. Since the Tunguska event of 1908 was an object of about this size, does that mean we're able to relax until about 2108, the two hundred year anniversary of that event? No, not at all, although it reflects a common error people make when dealing with statistics. For example, the odds of tossing a coin and having it come up heads 100 times in a row is very low (1 in a million trillion trillion). Now, let's say that we've tossed it 99 times and gotten heads each time. Does this mean that tails is "hot" and more likely on the next toss?

No, not at all. In fact, the coin might be uneven, and prone to landing on heads! Similarly, the 200-year average time for 30m asteroids striking the Earth is only an average—it doesn't tell us anything about particular asteroids. To make real forecasts, we must move from statistics into specifics, from mathematics to physics.

Take an example in another field: earthquakes. Some who call themselves earthquake researchers claim that it is principally impossible to predict specific earthquakes, and that the best we can do is have ideas of which regions are most prone to earthquakes, and set building codes and insurance rates appropriately. Leaving aside the fact that the most damaging earthquakes between 2000-2011 were in supposedly "low-risk" zones, this approach means that there's no ability to actually understand the process itself.*

When it comes to asteroids and comets, we are already doing better by looking at thousands of specific objects, but we must aim higher still: to understand the asteroids *as an entirety, rather than as individual objects*. New, dynamic principles of the interrelation of these bodies, as a system, are to be a priority for the future pursuit of science.

* See the LaRouchePAC Report, *Planetary Defense: An Extraterrestrial Imperative*, **LaRouchePAC.com/PDReport** and "The Emerging Science of Earthquake Prediction" in the Winter 2011-2012 issue of *21st Century.*



PLANETARY DEFENSE

Deflection and the Energy-Flux Density Factor

by Benjamin Deniston

Mankind is battling an array of natural disasters which continually pose a threat to life on this planet. Thanks to advancements in satellites and weather monitoring systems, our ability to forecast major storms and other extreme weather events is improving. Progress is being made in developing earthquake forecasting systems, designed to detect precursor signals which can provide early warnings before seismic events.[1] Even our Sun is being watched and analyzed more closely than ever, in an attempt to forecast "space weather" events and their effects on the Earth. However, there is another class of events that can not only be foreseen, but can be stopped from ever occurring. Asteroid and comet impacts represent a unique challenge, as we can take the necessary actions to see them coming, but also to ensure the Earth is never again struck in a catastrophic event. While it is likely that we will be able to control storms and certain extreme weather events in the not-too-distant future (if appropriate scientific/economic programs are pursued), for now asteroid defense can hold the title of the only currently preventable natural disaster.

But what are the factors determining our ability to defend the planet, and how can these limits be expanded? In defending the Earth from impacts, there are many possible scenarios we could face: a relatively small near-Earth asteroid on a short-term collision course, giving us little time to act; a large asteroid threatening a possible impact in a few decades, proving more time to act, but proving a larger foe; a worst case scenario of a large long-period comet only months away; and any number of possible variations in between.

The first line of defense is clear: *early detection*. No matter how large the threat is, the more warning time we have, the better off we will be. While asteroid and comet detection systems have been discussed in other locations,[2] the subject here is our ability to act on this knowledge. This takes us beyond just asteroid or comets per se, to a general consideration of our power for action within the universe.

Initial Considerations

To state the question in simple terms: 100 years ago we would have had no chance to defend the Earth from an asteroid or comet impact, while presently we have a limited ability to do so under certain circumstances, and in the future we could foreseeably develop the means to defend against threats currently outside of our defense capability – what determines these qualitative changes?

While there are countless important discoveries and technological innovations which have contributed to this process (and shouldn't have their importance dismissed), the subsuming role of ***energy-flux density*** will be considered here.[3]

1. See, *IGMASS: Towards International Collaboration in the Defense of Mankind,* "Progress in Seismic Forecasting," page 26, in this issue. See also, *Science Can Predict Earthquakes*, in the Winter 2011-12 issue.

2. In this issue see, "Strategic Defense of the Earth: Observation Systems," page 16.

3. "Energy-flux density" as specifically defined by Lyndon LaRouche, in his science of physical economics. For example, see, *So, You Wish to Learn All About Economics?: A Text on Elementary Mathematical Economics*, New York: New Benjamin Franklin Pub. House, 1984.

Table I
The Energy Density of Fuels

FUEL SOURCE	ENERGY DENSITY (J/g)
Combustion of Wood	1.8×10^4
Combustion of Coal (Bituminous)	2.7×10^4
Combustion of Petroleum (Diesel)	4.6×10^4
Combustion of H_2/O_2	1.2×10^5 (only H_2 mass considered)
Combustion of H_2/O_2	1.3×10^4 (Combined mass considered)
Typical Nuclear Fuel	3.7×10^9
Direct Fission Energy of U-235	8.2×10^{10}
Deuterium-Tritium Fusion	3.2×10^{11}
Annihilation of Anti-Matter	9.0×10^{13}

21st Century

Energy densities for wood, coal, and petroleum, do not include the mass of oxygen required for combustion, since in their typical applications, it is simply drawn from the atmosphere. Values for hydrogen combustion are given with and without considering the mass of oxygen.

This can be illustrated in first approximation by comparing the energy densities of successive power sources.

The significance is not simply found in the increase in energy, but in the physical economic implications: fundamental changes in the human species' space-time relationship with the universe, where leaps from one level to the next define new (previously impossible) modes of action. As in transportation, for example, development of systems associated with successive fuel sources create fundamentally new possibilities. On the Earth's surface, the locomotive revolution was associated with coal-fired engines, whereas the internal combustion engine required the advancement to petroleum. Airplane flight depends upon the higher energy to weight ratios of petroleum, but rocket travel from the Earth's surface to orbit (and beyond) has demanded the most efficient chemical combustion reactions possible.

Although transportation is only one expression of a broader qualitative change, it helps to introduce the concept of transformations in the physical boundaries of mankind's action within the universe. Taking this investigation further, only the energy densities of nuclear fission, to a limited degree, but ultimately thermonuclear fusion and matter-antimatter reactions, can truly provide mankind with efficient and timely access to the Solar System, as this reality is expressed in basic fuel and mass limitations. For example, we can measure the ratio of the total starting mass of a spacecraft (including all of its fuel) to its final mass upon arrival at its destination (in other words, measuring how much of the initial mass is the fuel required for the trip), and then compare how this ratio changes for different fuel sources (mass ratio). Or, the specific impulse can be determined by comparing how long one pound of fuel can provide one pound of thrust.[4]

Beyond the consideration of the energy density of a fuel source for transportation, higher levels of energy-flux density have systemic effects for the entire economy. The transitions from the hydrocarbon-based economy to the nuclear economy, and the yet-to-be realized, but desperately needed, transition to the fusion economy, are premier examples.[5]

Planetary Defense

For the asteroid and comet threats specifically, and ultimately the defense of all life on our planet, the ability to wield higher energy densities becomes crucial. We know for certain that there will be significant asteroid or comet impacts in the future. The question, then, becomes, will we take the necessary actions to deflect or destroy prospective threats before they hit?

This brings two interrelated aspects into focus: the energy required to influence the asteroids or comets themselves, and, even prior to that, the ability to reach the body in the first place.[6]

Moving spacecraft around the Solar System is not as

4. *The Role of Nuclear Power and Nuclear Propulsion in the Peaceful Exploration of Space*, IAEA, 2005; page 34, and Appendix VI (page 116).

5. For example, regarding mankind's entry into the nuclear age, see, "The Isotope Economy," J. Tennenbaum, *21st Century Science and Technology*, Fall-Winter 2006. Pertaining to fusion-related directed energy research see, "The Economic Impact of Relativistic Beam Technology," June 15, 1983; EIR Research Inc.

6. Again, this is not to dismiss the crucial role of finding and tracking asteroids and comets long before they may become a threat. While that absolutely must be done, here we focus on the ability to act on that knowledge.

Table II
Mass Ratio of Various Rocket Fuels

MODE	FUEL	MASS RATIO	SPECIFIC IMPULSE (Seconds)
Chemical	O_2/H_2	15 to 1	4,300
Fission	Heating Hydrogen Propellant (at 2,700 K)	3.2 to 1	9,600
Fission	Heating Hydrogen Propellant (at 5,000 K)	1.5 to 1	25,500
Fission	Heating Hydrogen Propellant (at 20,000 K)	1.2 to 1	66,000
Fission	Direct Fission of Uranium-235	1.001 to 1	13,000,000
Thermonuclear Fusion	Fusion of Hydrogen Isoptopes to Form Helium	1.0003 to 1	36,000,000
Annihilation of Matter	Matter-Antimatter Annihilation	1.00003 to 1	300,000,000

IAEA, LANL, *21st Century*

The mass/ratio values given here correspond to a particular trip made on an inertial (rather than continually accelerating) path. Changing the distance of destination and the desired acceleration rate would alter the values. For example, a three-day trip to Mars, undertaken with a constant acceleration and deceleration of 1-g, would give mass ratios of 1.007 for fusion, and an astronomical 1026 for chemical propulsion. Even 20,000K fission would have a mass-ratio of 50 for such an ambitious trip. Since constant acceleration also requires carrying all the fuel for the remainder of the trip, the fuel requirements increase exponentially with trip distance.

simple as moving from location A to location B, because we are dealing with orbits within a gravitational field. For example, current missions to Mars can only be launched at specific times (about every 2.17 years). This is not to wait for the planets to be close in terms of distance across Euclidean space, but it is when the orbital relationships of Earth and Mars provide a least-energy orbital pathway between them. Because changing an orbit requires a change in speed, space travel is often discussed in terms of the change in velocity required (or **delta-V**).

In the case of a potentially threatening near-Earth asteroid, for example, when decades of warning time are available, a minimal energy trajectory can be determined to intercept the asteroid, and the launch date can wait until the trajectories of the Earth and the target reach the positions which provide that relatively low energy path.

However, when there is not sufficient warning time to wait for this optimal timing, then the energy requirements can quickly jump many fold.[7] This would then require more fuel, meaning either a heavier spacecraft to start with, or a greater proportion of an unchanged total mass going towards fuel, leaving less mass free for the spacecraft upon arrival. For chemical propulsion, with its inherently low energy density, this is problematic, and can easily become untenable. But, relative to any specific scenario, higher levels of energy-flux density inherently have the potential to provide a greater delta-V. This underscores the need for more advanced propulsion systems, with fission playing a useful part, but a greater focus on the propulsion potential of fusion (while looking towards harnessing matter-antimatter reactions), in order to truly open up mankind's efficient access to the Solar System.

Defense

When it comes to altering the path of an asteroid or comet to ensure it misses the Earth, various methods have been considered, and are often categorized into different types. For example, there are "slow-push-pull" methods, in which a small amount of force is exerted over a long period of time to slowly alter the path of the asteroid or comet, and there are "quick" methods, in which a large amount of force is applied over a short period of time.[8]

Relative to many of the asteroids or comets in question, even applying an intense burst of energy quickly may not amount to much of an effect. To use the example provided in the 2010 National Research Council report cited

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7. See, *Defending Planet Earth: Near-Earth Object Surveys and Hazard Mitigation Strategies*, page 80-84. National Research Council, 2010.

8. For a more detailed description of each of the following methods, and the particular benefits or limitations of each, see Chapter 4, "Preventing or mitigating an impact," of *Dealing with the Threat to Earth from Asteroids and Comets*, IAA, 2009 (pages 50 to 67); and Chapter 5, "Mitigation," of *Defending Planet Earth: Near-Earth Object Surveys and Hazard Mitigation Strategies*, National Research Council, 2010 (pages 66-88).

above, if we want to change the position of an asteroid by 2.5 Earth radii (enough to ensure if misses the Earth), this could be done by hitting the target with a kinetic impactor, to either speed it up or slow it down by a tiny amount (only 1 centimeter per second), if that speed change is induced *10 years* prior to the feared impact. The 10 year period is required for the small speed change to culminate in a large enough displacement of the target's future position. For certain medium-sized asteroids this is possible with current technologies, assuming we have a few decades of warning time.

If, instead of a kinetic impact, a gravity tractor were used, it would also have to begin exerting a small gravitational pull on the asteroid in question years to decades before the impact date (depending on the target's size), but in this case continuously applying its gravitational potential for the entire time, in order to ensure the asteroid misses the Earth.

As a function of the size of the asteroid in question and the amount of time available to act, different deflection options can be compared together on one chart, showing their effectiveness for different time and size scenarios. Such comparisons have been done as part of comprehensive reports on planetary defense, such as the examples in the graphs on the following page.

These comparisons of mitigation options consistently show that nuclear explosive devices are the most powerful currently available, and, hence, the only option in the cases of short warning times or large objects. However, to see what can be done with new technological developments, we must look to the role of energy-flux density as the determining factor of various mitigation methods.

Slow-Push-Pull Methods

Gravity tractor
Using the mass of a spacecraft to gravitationally pull on the target

Attached thruster
Placing a thruster on the target, used to push it off course

Laser ablation
Using a laser to continuously vaporize a small area on the surface of the target, creating a thrust

Mass driver
An apparatus to throw the target's own material off its surface, pushing it away

Alteration of reflective or thermal properties
Painting or covering the surface of the target, changing its interaction with the Sun's radiation and very slowly altering its path

Quick Methods

Kinetic impact
Directly hitting the target with a spacecraft at a high speed

Nuclear explosive device
Using a nuclear explosive to disrupt the trajectory of the target

Hypervelocity Kinetic Impact:

The 1992 *Near-Earth Object Interception Workshop*, held at Los Alamos National Laboratory, brought together an array of specialists contributing to various aspects of the planetary defense challenge. Included in the proceedings was a study demonstrating that in certain scenarios, a kinetic impactor can actually match the deflection potential previously only thought achievable with a thermonuclear warhead, *but only when utilizing speeds achievable only by a variation of nuclear propulsion*. This hypervelocity kinetic impact was based on the famous Project Orion, a 1960s program to develop a spacecraft that would be propelled by a series of small nuclear bombs, released out the back of the ship and then detonated behind its "pusher-plate," propelling the spacecraft. Although a fair amount of design and preparatory testing was done, Orion never got off the ground.[9]

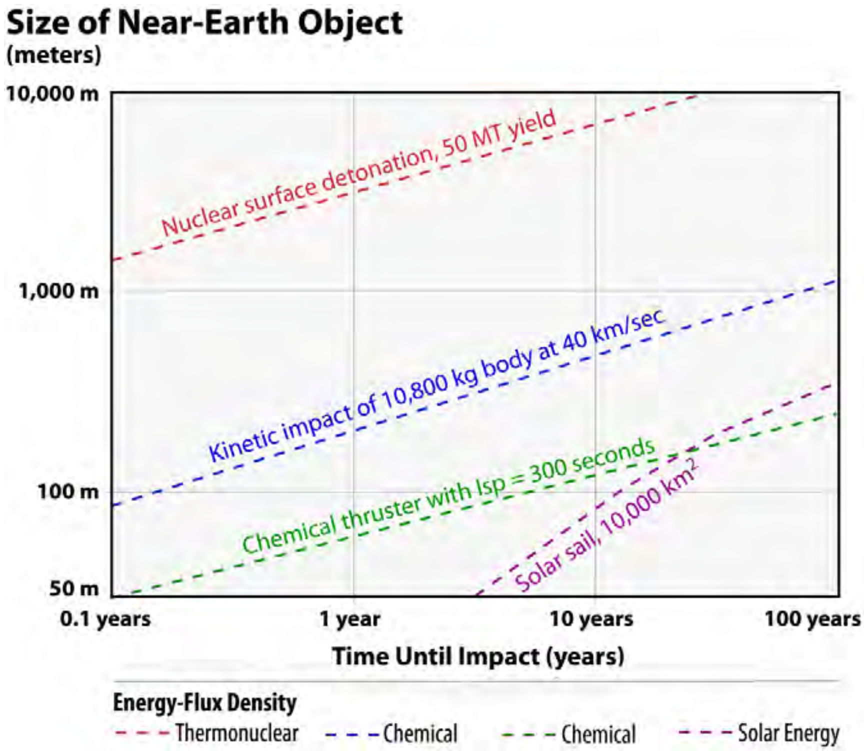
This 1992 study ends with a specific scenario in which we would only have a short warning time, and our intercepting spacecraft could only be launched when the asteroid was only 17 hours from impact (at a distance of 1.5 million km). Comparing an Orion-like propulsion system and a standard chemical propulsion system, the author showed that the nuclear explosive propulsion design would be able to reach the target in less than 1/25th the time, and at a speed 85 times greater! As the author concluded, "the exceedingly high

9. Despite this, the general concept is still sound, and could even be advanced farther with current technologies.

relative velocities provide sufficient kinetic energy to deflect these malignant astral bodies without resorting to an explosive warhead, nuclear or otherwise."[10]

Nuclear-Electric Propulsion:

Currently Russia's Keldysh Center, Energia, and Rosatom are developing the first-ever megawatt-class electric spacecraft, using a small nuclear reactor to generate electricity to power an ion propulsion system. Despite the low thrust of electric propulsion, the very high specific impulse of this system and the ability for continuous propulsion throughout the mission expands our capability for rendezvous missions, for either mitigation (e.g. gravity tractor) or for science and characterization (determining what the asteroid or comet is made of). This will be a vast improvement over existing solar-electric propulsion systems, and entering megawatt levels of electricity generation in space will expand the number and power of scientific instruments available to spacecraft and satellites (current systems are measured in the tens of kilowatts).[11]

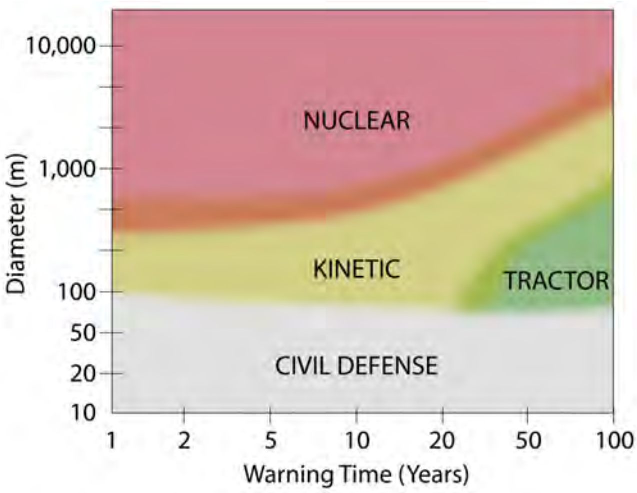


Reproduced from *Dealing with the Threat to Earth from Asteroids and Comets*, IAA, 2009, p. 66.

Nuclear-Thermal Propulsion:

Part of the 1992 Los Alamos Workshop was a technology assessment, indicating future technologies which could be developed with applications to planetary defense. Included was a brief analysis of the general benefits of nuclear-thermal propulsion systems, in which a nuclear reactor is used to heat and expel hydrogen as a propellant. Compared with existing chemical systems, nuclear-thermal propulsion promises either substantially lower launch mass for comparable missions, or quicker intercept speeds.[12]

Nuclear rockets with hydrogen propellant offer significant performance benefits over chemical rockets. They have much higher specific impulse, on the order of ~1,000 seconds compared to 450 seconds for H_2/O_2 rockets. This higher specific impulse allows nuclear rockets to achieve substantially higher final velocities than chemical rockets, at least twice as great for comparable launch weight. Alternatively, for comparable final velocities and payload, nuclear rockets can be a factor of



Adapted from *Defending Planet Earth: Near-Earth Object Surveys and Hazard Mitigation Strategies*, National Research Council, 2010, page 85.

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10. "Nuclear Explosive Propelled Interceptor for Deflecting Comets and Asteroids on a Collision Course with Earth," J. C. Solem, *Proceedings of the Near-Earth Object Interception Workshop*, Los Alamos National Laboratory, New Mexico, 1992, January 14-16, pages 121-130.

11. "The role of space power in solving prospective problems in the interests of global safety, science and social economic sphere," 2010, presentation by A. S. Koroteyev, Director of SSC Keldysh Research Centre, Academician of Russian Academy of Sciences.

12. Workshop Summary, "Assessment of Current and Future Technologies," *Proceedings of the Near-Earth Object Interception Workshop*, Los Alamos National Laboratory, New Mexico, 1992, January 14-16, pages 225-234.

three to four lower in launch mass. These performance advantages are of potential benefit for NEO-intercept missions. For close-in intercepts, high velocity translates into quicker intercepts, reducing the level of risk and amount of delta-V deflection required. For distant intercepts, lower launch mass translates into lower cost. Extensive testing of nuclear engines has been carried out by the U.S. in the NERVA program, and by the former USSR. The basic feasibility of nuclear rockets has been well established. Recently, the SNTP particle bed nuclear rocket program has been disclosed by the U.S. Department of Defense. This program [was] developing a compact nuclear rocket with very high thrust/weight ratio.

Table III
Propulsion Comparisons

	CHEMICAL PROPULSION	NUCLEAR EXPLOSIVE PROPULSION
Specific Impulse	500 seconds	42,500 seconds
Rocket Velocity	6 km/second	821 km/second
Intercept Range	29,300 km	1,460,000 km
Intercept Time	804 minutes	30 minutes

"Nuclear Explosive Propelled Interceptor for Deflecting Comets and Asteroids on a Collision Course with Earth," J. C. Solem, *Proceedings of the Near-Earth Object Interception Workshop*, Los Alamos National Laboratory, New Mexico, 1992, January 14-16, page 121-130.

In 2011 a more detailed study examined how nuclear thermal systems can increase our capability to handle worst-case scenarios. Long-period comets can come at us with little warning, and often at higher speeds than asteroids. While thermonuclear explosives provide the greatest deflection capability, the propulsion systems available to deploy them still remain a limiting factor. The 2011 study, "Near-Earth object interception using nuclear-thermal rocket propulsion," showed that by reducing fuel weight requirements, nuclear-thermal propulsion increases the maximum size that could possibly be dealt with.[13]

> Comparison of propulsion technologies for this mission shows that NTR [nuclear thermal rocket] outperforms other options substantially. The discussion concludes with an estimate of the comet size (5 km) that could be deflected using NTR propulsion, given current launch capabilities.

In Defense of Progress

A variety of different mitigation options have been considered, each with particular benefits and short falls relative to specific scenarios. Given our current technological capabilities, only a few of these options are currently available, although studies, such as those cited above, do provide an indication of what can be possible with future technological developments. However, the point here is not to advocate one specific option, but to examine the considerations which cut across various options, and can provide mankind with a broad-based capability to act in the Solar System.

As discussed above, kinetic impacts can reach the capabilities of thermonuclear explosives, but only when accelerated with nuclear-explosive propulsion. The capabilities of electric propulsion for rendezvous missions to characterize and study asteroids or comets, or to utilize a gravitational tractor method to alter their trajectories, can be greatly improved when nuclear-electric is utilized instead of solar-electric. With nuclear-thermal propulsion for planetary defense, launch mass and intercept times can be reduced, and we can handle larger threats than we could with chemical propulsion systems. Even the fundamental geometry of our access to the Solar System can be revolutionized with the capabilities of nuclear fission and fusion propulsion systems.

Nuclear power is an invariant in improving our capabilities, and the concept of energy-flux density must be taken as a determining factor in planetary defense. Our nuclear fission and thermonuclear fusion capabilities in space, as a broad set of technologies, must be pursued to qualitatively transform our time-space access to, and action within, our Solar System. The best path to do this is to adopt a science-driver mission to force the challenge of making these breakthroughs. For example, developing fusion propulsion systems capable of transporting human beings to and from Mars at a constant acceleration/deceleration of 1-gravity (1-g) could be that challenge. Achieving this capability for 1-g space travel over the course of a generation or two will provide the technologies to deal with the threats posed to the Earth. This applies to defense, but also situates defense as a subsumed factor of general scientific and economic advance, in space and on Earth.

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13. X. L. Zhang, E. Ball, L. Kochmanski, S. D. Howe, "Near-Earth object interception using nuclear thermal rocket propulsion," *Proceedings of the Institution of Mechanical Engineers Part G - Journal of Aerospace Engineering*, 2011; 225 (G2 Sp. Iss): 181-193.

Toward Collaboration In the Defense of Mankind

by Benjamin Deniston, Pavel Penev, and Jason Ross

Currently, mankind lives on only one planet. We are all subject to similar threats: threats that do not distinguish among nations, religions, political parties, or social classes. Irregular solar activity, earthquakes, volcanic eruptions, floods, asteroid and comet impacts — these events don't contemplate national boundaries before they strike. So why should we, when defending ourselves from them?

The conference banner. About 35 scientists addressed the three-day conference.

This was the issue underlying a scientific conference, "Space and Global Security of Humanity," held in Yevpatoria, Ukraine, Sept. 3-6, 2012, bringing together scientists from mainly Russia and Ukraine, with attendees from Kazakstan, Belarus, Germany, and Canada. The only U.S. participation came from two representatives of the LaRouche Policy Institute, Benjamin Deniston and Jason Ross, who presented the leading political, economic and scientific work of Lyndon LaRouche's movement in the United States. The conference was sponsored by a number of large Russian, Ukrainian, and international organizations,[1] but centered around the activity of the International Global Monitoring Aerospace Systems organization, IGMASS.

Although the IGMASS proposal has existed for a few years, this particular conference came in the context of Russia's Strategic Defense of Earth (SDE) offer from Fall 2011, a proposal for collaboration between the United States and Russia on both missile defense systems and defending the entire Earth from the threats posed by future asteroid and comet impacts.[2] Seeing this particular SDE proposal as an upgraded re-offer of his original 1983 program which became the Strategic Defense Initiative (SDI), Lyndon LaRouche and his associates have very publicly and forcefully supported it, most recently in the 68-page LaRouchePAC report *The Strategic Defense of Earth*.[3]

IGMASS is a proposed "system of systems," an organi-

1. The State Space Agency of Ukraine, the Space Research Institute of the National Academy of Sciences of Ukraine and National Space Agency of Ukraine, the International Academy of Astronautics, the Russian Academy of Cosmonautics, the International Znanie (Knowledge) Association, and the company Russian Space Systems.

2. See "As World War Threatens, Russia Proposes SDE," EIR, Nov. 25, 2011, http://www.larouchepub.com/eiw/public/2011/eirv38n46-20111125/53-56_3846.pdf

3. For more on the SDE, see the introduction and section two of that report, "Redefining Defense: The Science-Driver Principle," available at http://larouchepac.com/SDE

The conference prepares to convene in Yevpatoria, Ukraine (right). Below, LaRouche Policy Institute representatives Jason Ross (left) and Ben Deniston with a Soviet-era space capsule, at a museum of the State Space Agency of Ukraine, in Yevpatoria.

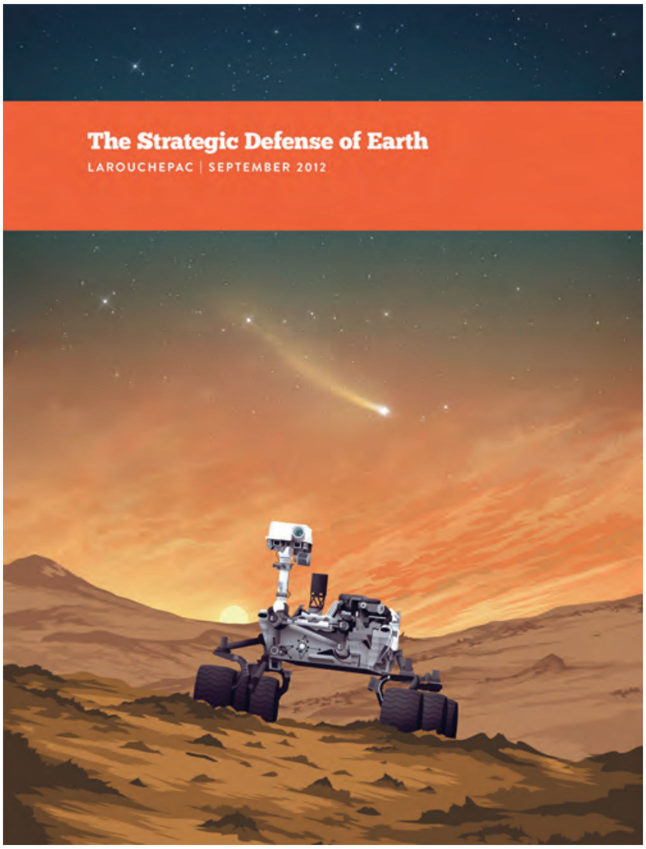
LaRouche Policy Institute

zation that would integrate various existing, and potentially new, satellite, air, and ground-based monitoring systems from nations all around the world, to provide a unified real-time capability to monitor the planet and the surrounding regions of space for a broad range of potential threats to life on Earth. The idea of integrating and sharing the information from satellite and other observational systems is not new, with various somewhat parallel ideas moving forward at the United Nations and other associations. While IGMASS will tap into these other systems, creating a centralized system of systems, it also sets itself apart from most others by focusing on the signals appearing *prior* to a disaster, the *precursors* of both man-made and natural disasters, and using these precursors for the purpose of *forecasting disasters before they strike*.

This crucial distinction is perhaps most evident in the forecasting of seismic events (earthquakes, tsunamis, and volcanic activity). While reductionists, fearful of the rigid structure of what is and is not accepted in academia, waste their breath (and our time) by blindly insisting that forecasting of seismic events is simply impossible, a series of presentations at this conference made clear that the science of forecasting seismic events, while not yet perfect, is moving forward, and successful forecasts have been made through a pilot project of the IGMASS system conducted by Russia over the past year. While this itself will be a revolution in the defense of mankind, IGMASS as a whole is a much broader proposal.

The forecasting possibilities discussed extend from the potential damage resulting from forest fires and floods (as well as man-made industrial disasters); to the threats of incoming asteroids, meteorites, and comets; to how the Sun influences seismic activity on Earth, human health, and space weather (the radiation, electrical, and magnetic fluctuations we experience on and around the Earth caused by solar and galactic activity). In order to be successful in understanding, responding to, and forecasting these terrestrial and cosmic conditions, the idea of expanding an integrated Earth and space monitoring system becomes crucial.

Before getting into the depth of what was presented at this conference, we must note in prelude that these considerations already take us to some very profound considerations. As LaRouche discussed in his recent publication,



Chris Jadatz

A Special Report available at
http://larouchepac.com/SDE

"Next, Beyond Mars,"[4] the power of mankind to advance is directly related to recognizing the failure of our sense perceptions, and understanding the qualitatively distinct power of the human mind. An integrated system of systems, monitoring the otherwise invisible processes that influence and control the conditions on our planet, becomes *a synthetic sensorium which changes the human species as a whole*. The advancement of mankind is directly tied to the unique power of the human mind to create new synthetic sensory systems, expanding its domain of action. IGMASS expresses a potential to consciously integrate and expand the powers of the human mind to a degree never before realized.

As the global nature of these threats illustrates — it would only take one large long-period comet to wipe out human civilization with a single impact — the continued existence of the human species depends upon casting aside our reliance upon our simply biological sense perceptions, and moving into a science-driven program to expand the power of the mind to sense and to act, all around the Earth and throughout the Solar System. As will become clear below, this means understanding the Earth as an integrated part of the Solar System, not one floating in empty space, but intimately connected through various processes which we can now come to understand for the purposes of forecasting extreme events, and, even if in a limited degree at first, begin to control.

Such international collaboration in the defense of all mankind is not just a "nice" policy, but is of profound significance for the advancement of humanity as a whole. Seen from a historical vantage point, this becomes a potential coming-of-age test for humanity: *Can nations come together to overcome the existential challenges posed to all mankind*?

The Context

At the IGMASS conference, the political and economic crises currently facing the world were not overlooked by the participants. While some aspects were touched upon anecdotally in a few presentations, Jason Ross of the LaRouche Policy Institute was the most clear in addressing this reality. Citing the immediate danger of President Obama and his backers in the British Empire taking the world to the brink of thermonuclear war, Ross made clear that this is not the desire of the majority of Americans, and that there is extremely significant opposition, led by LaRouche and top levels of the U.S. military institutions, to Obama's British policy of conflict with Russia and China in particular. The current conflict around NATO's missile defense systems in Eastern Europe, and the closely related issue of trans-Atlantic economic disintegration, can both be overcome with the types of scientific programs exemplified by IGMASS and the SDE, Ross stressed.

After setting the stage, Ross followed up with a presentation of the fundamental principles of scientific progress and economic growth. As was demonstrated with the Apollo program, true science-driver programs not only generate a net profit, but produce a type of economic growth that is fundamentally transcendental in nature: growth whose value is incommensurate with the cost to achieve such growth. The new scientific and technological capabilities developed in a true science-driver program generate wealth by creating completely new capabilities within the economy, ones which simply didn't exist before. Such new platforms for the economy as a whole cannot be understood on the basis of local profit. Current arguments that these programs "cost too much money" and "cannot be afforded" are simply absurd; quite the contrary, we cannot afford *not* to pursue them.

This view of IGMASS and planetary defense from the perspective of a science of physical economics was well

4. "SDI Today!: Next, Beyond Mars," EIR, Aug. 31, 2012, http://www.larouchepub.com/eiw/public/2012/2012_30-39/2012-34/pdf/52-58_3934.pdf

received by the audience, and was followed up by the second LaRouche Policy Institute representative, Benjamin Deniston, who elaborated on what types of science-driver programs will provide the greatest benefits in both improving mankind's defense against potentially hazardous asteroids and comets, and generating economic growth. Focusing on LaRouche's concept of *energy-flux density*, Deniston showed that the next revolution in our ability to act in deep space will necessarily come with the developments associated with nuclear fission and fusion propulsion systems. These do not simply provide a power source, but express an entirely new stage of the economic power of mankind, a new *economic platform*, which will upshift the entire physical-economic capability of the human species, including the crucial issue of an expanded capability to defend against the threats of asteroids and comets.

Stimulating a fair amount of side discussion about these political and economic considerations, this pair of presentations provided an important contribution from the United States, in the midst of what was already a very high-level and provocative conference.

About 35 scientists made presentations on various aspects of the IGMASS program and related activity over the three-day event. The keynote was delivered by Prof. Anatoly Perminov, former head of the Russian Federal Space Agency (Roscosmos), and current chairman of the International Committee on the IGMASS Project Implementation.[5]

NASA/Bill Ingalls

Anatoly Perminov (right), former head of Roscosmos, keynoted the conference. Here he is shown on Oct. 2, 2009 with NASA Administrator Charles Bolden, at Mission Control Center in Korolev, Russia, after a successful docking of the Soyuz TMA-16 with the International Space Station.

What Is IGMASS?

Perminov clarified the objectives of the IGMASS program, with a strong emphasis on moving towards a global forecasting capability to provide early warning of threats. The full range of disasters monitored as part of IGMASS includes:

- industrial accidents, disasters, and catastrophes
- anomalous solar activity, space debris, asteroid and comet dangers
- earthquakes, tsunamis, volcanic activity
- natural fires
- landslides, mud flows, avalanches
- floods and droughts
- dangerous weather

To monitor these events themselves, and various forms of early signals which may precede some of them (precursors), many different parameters are to be continuously observed and measured (ionospheric disturbances, space debris in low-Earth orbit, vibrations in the Earth's crust, shifts of the Earth's surface, precipitation, water levels, general atmospheric conditions, cloud cover, etc.). For this purpose, numerous land-, air-, and satellite-based systems from various nations will provide the measurements of these parameters, feeding all the information into centralized data centers where it can be integrated, cross-compared, and analyzed. From there, forecasts, warnings, and response assistance can be issued to the relevant governments and institutions.

Perminov went on to say that for monitoring purposes, key projects that either already exist, or are in the process of being developed, could all feed into the IGMASS system of systems. These include international, regional, and other programs consisting of satellite constellations, information-sharing centers, and other observing systems (Table 1).

While the full realization of an IGMASS system has yet to be achieved, Russia has pursued the concept since

5. Perminov is also the vice president of the International Academy of Astronautics and the deputy designer general/director general of the company Russian Space Systems.

Table 1
INTERNATIONAL, REGIONAL, AND OTHER PROGRAMS THAT CAN BE INTEGRATED INTO IGMASS
Presented by Anatoly Perminov

INTERNATIONAL PROJECTS	• **GEOSS**— A system to link together existing and planned observation systems around the world and support the development of new systems where gaps currently exist. • **Disaster Charter** — Aims at creating a unified system to provide satellite data to those affected by natural or manmade disasters. • **UN-SPIDER** — Operates under the United Nations Office for Outer Space Affairs to use existing satellite systems for disaster management and emergency response.
REGIONAL PROJECTS	• **Sentinel Asia** — A program led by the Asia-Pacific Regional Space Agency Forum to support disaster management in the Asia-Pacific region by using Earth observation satellite data. • **GMES** — Global Monitoring for Environment and Security is a joint program of the European Commission and ESA to pull together information from environmental satellites, air and ground stations to study the Earth's systems. • **SERVIR** — A joint program between NASA, USAID, the World Bank, and the Central American Commission for Environment and Development (CCAD), to provide satellite data to developing nations. • **DMC** — The Disaster Monitoring Constellation is a number of remote sensing satellites operated for the Algerian, Nigerian, Turkish, British and Chinese governments for emergency Earth imaging for disaster relief.
SYSTEMS FOR TELECOMMUNICATIONS, SPACE MONITORING, GLOBAL NAVIGATION, ETC.	• **GALILEO** — Satellite navigation system currently being built by the EU and the ESA. • **GLONASS** — Russia's global positioning system, the only system comparable to the U.S. GPS system. • **Space Monitoring System** — Russia plans on launching four satellites to study the hard-to-reach regions around the North Pole.

Figure 1
STAGES OF THE REALIZATION OF THE IGMASS PROJECT
Presented by Valery Menshikov

1. **Exploratory Research and Development (2007–2011)**
   a. Analysis of engineering and technological capabilities for the creation of elements of the system
   b. Study of the precursors of natural and technogenic disasters, as well as the possibilities of using instruments to record these precursors
   c. Development of the IGMASS concept
   d. Engineering and economic analysis of conditions for the creation, development and functioning of the system
   e. IGMASS system design (development of technical specifications for creation of the system, and its elements)
      • 10 million rubles
2. **Preliminary Design of a Pilot Version of the System in Russia (2012–2014)**
   a. Preliminary design, creation of experimental modules and key elements of the system, development of technical documentation for the manufacture of experimental samples (2012–2013)
   b. Development of models of how the system and its elements' will function (2013–2014)
   c. Creation and testing of the functional subsystems of IGMASS, and adjustment of the technical documentation (2014)
   d. Systematic testing, preparation of technical documentation for mass production (2014)
      • 2,500 million rubles
3. **Creation of a Pilot Version of the System in Russia (2015–2017)**
   a. Fine-tuning the system's ground-based infrastructure (2015)
   b. Deployment of a specialized small spacecraft constellation (2016)
   c. Pre-deployment work on ground infrastructure for the data reception and processing (2015)
   d. Integration of system elements with its international counterparts, integration of monitoring data (2016)
   e. Fine-tuning of ways to achieve the prospective objectives of IGMASS (threats in and from space) through broad international cooperation (2015–2017)
   f. Full-scale testing of functional elements of the system (2016)
   g. Comprehensive testing of the system (2017)
   h. The system goes operational (2017)
      • 7,490 million rubles


Valery Menshikov

2007, and in 2012 started designing and even operating limited aspects of a pilot version. The history and status of this program, as well as some initial results of the pilot project, were presented by Prof. Valery Menshikov, the chief designer of IGMASS, and vice chairman of the International Committee for the Realization of the IGMASS Project (Figure 1).

Menshikov highlighted

September 2010, when the First Deputy Prime Minister of the Russian Federation, the Foreign Ministry, the Russian Academy of Sciences, the Energy Ministry, the Economic Development Ministry, and the Finance Ministry, were all requested to "review the question of implementing the proposal to create an International Aerospace System for Global Monitoring [IGMASS], including resource procurement for the job." All ministries and institutions (with the sole exception of the Finance Ministry) gave a positive evaluation. The Russian Federal Space Agency also sent a "Plan of Top-Priority Measures in 2010-2011 for Implementation of the Proposal to Create IGMASS" to the Russian Academy of Sciences, the Foreign Ministry, the Ministry of Emergencies, the Economic Development Ministry, the Ministry of Regional Development, and the Finance Ministry.

N.N. Novikova

Progress in Seismic Forecasting

Perhaps the clearest examples of the forecasting potential of IGMASS is the ongoing study of the precursor activity that occurs before an earthquake, tsunami, or volcanic eruption. It is hoped that many lives can be saved in the future by monitoring for these precursor signals in order to give early warnings of when and where a seismic event may occur, and how large it may be. This was emphasized by Perminov in his keynote[6] and in other overview reports, and then elaborated in greater detail in four other presentations.

Two of the presentations were by representatives of the Research Center for Earth Monitoring (http://eng.ntsomz.ru/), which directly receives and analyzes data from satellites which continuously monitor the Earth; it is run by the company Russian Space Systems[7] for Roscosmos. Included in its broad array of operations, the Research Center for Earth Monitoring watches for forest fire dangers, potentially dangerous asteroids and comets, and has started a new program to seek out seismic precursors, in an attempt to forecast earthquakes and volcanic activity. Earlier this year, an experimental program was initiated at the center, Project ES SFM (http://www.ntsomz.ru/projects/earthquake), aiming to test real-time seismic forecasting capabilities, and attempting to achieve a targeted objective posed by the Russian Academy of Sciences and the Russian Ministry of Emergencies. Focusing on earthquakes with magnitude 6.0 or greater in the Pacific region of the Kamchatka Peninsula, the Kurile Islands, Sakhalin Island, and Japan, the center made three successful forecasts between May and September 2012.[8]

Although it is a still-improving practice, this initial progress was highlighted by N.N. Novikova of the Research Center for Earth Operative Monitoring, in her presentation about Project ES SFM. Novikova discussed the three successful forecasts issued to the Council of Experts of the Russian Academy of Sciences (Table 2), and described the nature of Project ES SFM.

This was followed by a presentation by L.N. Doda, another representative of the Research Center for Earth Operative Monitoring and a participant in Project ES SFM. He included an overview of the methodology used for their earthquake forecasting. What he referred to as the "seismo-tectogenic conception" utilized by the center, is based upon the interaction of a number of factors: gravitational anomalies from shifting mass, local indications from a special analysis of cloud cover, the motion of gases throughout the structure of the Earth, the interaction of the solar/interplanetary magnetic field with the Earth's magnetic field, instabilities in the Earth's rotation, the association of magnetic meridians with tectonic processes, and the effects of solar activity on the Earth ("geoeffective" phenomena) in triggering earthquakes.

A number of satellite- and ground-based systems that monitor these processes are utilized by the center to produce composite maps of key conditions (Figure 2). Then specific criteria are used to identify what types of activity constitute a serious warning of a potential seismic event, where it may be, and how large. Doda discussed several examples of the work done at the center, focusing on specific seismic events and the analysis of the conditions leading up to these events, from the standpoint of the seismo-tectogenic conception.

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6. Perminov cited the example of Japan's March 2011, 9.0 Tohoku earthquake and subsequent tsunami which killed over 15,000 people. After the event, analysts went back to examine the recorded data from satellites and other observational systems, finding multiple, independent precursor signals indicating an oncoming major earthquake, days in advance. This case had already been presented to LaRouchePAC-TV on April 11, 2011, by Prof. Sergey Pulinets, http://larouchepac.com/node/17944

7. Russian Space Systems is one of the main supporters of the IGMASS conference, and is crucial to Russian space capabilities. It runs Russia's global positioning system, GLONASS, among many other vital tasks. The company was formed from former Soviet design bureaus which represented a core part of the Soviet space program.

8. For more on this experimental operation on seismic forecasting see http://eng.ntsomz.ru/projects/earthquake/doda_news120712eng

Table 2
FORECASTS OF THE RESEARCH CENTER FOR EARTH MONITORING
Presented by N.N. Nonikova

Forecasts	Actual Events
May 4, 2012 — Forecasts of a possible powerful earthquake in Japan by May 16. http://www.ntsomz.ru/projects/earthquake/doda_news240412	**May 19-20, 2012** — Three earthquakes of magnitudes 5.9, 5.9, and 6.4 occurred on Honshu island, Japan.
June 15, 2012 — A forecast of a possible strong earthquake between June 20 to 30 was registered with the Expert Council of the Russian Academy of Sciences on June 15, 2012. http://www.ntsomz.ru/projects/earthquake/doda_news240412	**June 17, 2012** — Magnitude 6.4 earthquake on Honshu island, Japan. **June 24, 2012** — Magnitude 6.1 earthquake on Kamchatka .
July 6, 2012 — A forecast was registered with the Council of Experts of the Russian Academy of Sciences warning of "an earthquake with magnitude 6.8 (± 0.2) … on Kamchatka … or deep in the Sea of Okhotsk with a greater magnitude" most likely between July 20 and 30. The forecast also indicates the likelihood of a July earthquake in Japan. http://www.ntsomz.ru/projects/earthquake/eq27072012 **July 31, 2012** — A letter extending the July 6 forecast to August 17 was submitted to the Council of Experts. http://www.ntsomz.ru/projects/earthquake/eq27072012 p. 16. **July 18, 2012** — Also at a symposium on natural disasters, Sergey Pulinets warned of, "the approach of an earthquake with magnitude on the order of 6 in the Kamchatka-Kuril region. According to our estimates, it must occur in 5—6 days." http://www.ntsomz.ru/files/art_gisa.docx	**July 20, 2012** — Magnitude 6.1 and 5.8 earthquakes in southern Kamchatka. **Aug. 17** — Magnitude 7.7 earthquake in the Sea of Okhotsk (between Kamchatka and the mainland) 625 km deep.

Figure 2
EARTHQUAKE SYMPTOM MONITORING SYSTEMS
Presented by L.N. Doda

1. A system of 9-channel gravimetry stations at the Tula State University (developer: Dr. O. V. Martynov)
2. Strain measurement stations (dev.: I. & V. Stepanov)
3. Subterranean proton measurement stations in Petropavlovsk-Kamchatsky and Chieti (Italy) (dev.: D. A. Kuznetsov, director: V. S. Bobrovsky)
4. Electrotelluric measurement stations in Japan and Greece (Kakioka, Memanbetsu, Kanoya; Athens, Pyrgos)
5. Data from Russian and foreign Earth remote-sensing and cloud cover satellite systems with specialized processing at the Research Center for Earth Operative Monitoring to identify cloud seismo-tectonic indicators and other symptoms in satellite photographs
6. Database of the Paris Observatory's Earth Rotation Service
7. Heliogeophysical parameter databases of various nations

Systems utilized by Project ES SFM of the Research Center for Earth Monitoring in the experimental seismic forecasting program. Translated from Slide 6 of Prof. Doda's presentation, http://www.ntsomz.ru/files/present_doda.pptx

When they have credible indications of an oncoming seismic event, they send a letter to the Council of Experts (Figure 3).

In addition to the practical progress in the science of earthquake forecasting, what also stood out to the authors of this article is both the recognition of solar effects on the Earth's seismic processes, and of the *necessity* to incorporate these effects for accurate forecasting. The Sun's activity can fluctuate wildly, at times bombarding the Earth and its magnetic field with intense bursts of material thrown off from the Sun's atmosphere and surface. Geomagnetic storms, extreme weather, and even certain human health conditions are all either known or suspected to be linked to these solar events. The implications of studies conducted at the Research Center for Earth Operative Monitoring over the past year provide strong evidence for linking certain earthquakes to the Sun's activity as well (this is by no means the first time this hypothesis has been introduced or tested).[9]

9. For example, see, "Possible Correlation between Solar Activity and Global Seismicity," by Jusoh Mohamad Huzaimy and Kiyohumi Yumoto, *Proceedings of the 2011 IEEE International Conference on Space Science and Communication* (IconSpace), July 12-13, 2011, Penang, Malaysia.

В РОССИЙСКИЙ ЭКСПЕРТНЫЙ СОВЕТ ПО ПРОГНОЗУ ЗЕМЛЕТРЯСЕНИЙ И ОЦЕНКЕ СЕЙСМИЧЕСКОЙ ОПАСНОСТИ

От члена РЭС **Доды Леонида Николаевича**
Тел.: , e-mail:

Уважаемый Александр Иванович!

Прошу зарегистрировать и дать экспертную оценку следующему комплексному прогнозу: до 4 июля 2012 г. в одной из потенциальных зон, представленных на прилагаемой сейсмопрогнозной карте в виде желтых овалов, возможно землетрясение с магнитудой М6.5-7.0 (±0,2). Вероятные даты указаны в условных обозначениях сейсмомеридианов в легенде карты, пересекающих указанные зоны. Высока вероятность подобного ЗМТ в Японской зоне и на Камчатке с магнитудой М6.0+.

Прогнозная карта на июнь 2012 г. и композит с облачными сейсмоиндикаторами отправлены Вам по электронной почте 15 июня.

Л. Дода
15.06.2012

Реализация: 1.17.06.2012-20:32-(38,9;141,9)-М6,4-Н32-вост. Хонсю

2.24.06.2012-03:15-(57,6;163,0)-М6,1-Н17-с/в Камчатки

http://www.ntsomz.ru

Figure 3
LETTER FROM L.N. DODA TO THE RUSSIAN EXPERT COUNCIL ON EARTHQUAKE FORECASTING AND EVALUATION OF SEISMIC DANGERS

An earthquake forecast from L.N. Doda of the Research Center for Earth Monitoring, June 15, 2012. Translation of the letter: "Kindly record the following integrated forecast and provide an expert evaluation of it: An earthquake with magnitude M6.57.0 (±0.2) is possible before July 4, 2012 in one of the potential zones shown on the attached seismic forecast map in the form of yellow ovals. The likely dates have been indicated in the map legend by notations corresponding to where the seismic meridians intersect the indicated zones. There is a high probability of such an earthquake with magnitude M6.0+ in the Japanese zone, and on Kamchatka.

"The forecast map for June, 2012, and the composite with cloud seismic indicators were e-mailed to you on June 15."

Realization: 1. June 17, 2012-20:32-(38.9; 141.9)-M6.4-H32-Eastern Honshu

2. June 24, 2012-03:15-(57.6; 163.0)-M6.1-H17-by/on Kamchatka

In the seismo-tectogenic conception, the solar-earthquake relationship is mediated through the Earth's magnetic field. On the one side, recent studies at the center claim to show strong evidence that seismic activity can be triggered by geomagnetic activity[10] (which they take into account in their forecasting); while on the other side, it has been long known that solar activity can cause large-scale fluctuations in the geomagnetic field (geomagnetic storms). As discussed above, this is not the only factor to consider, but the practical necessity to include it is highly significant for understanding the integrated connection among the Earth, the Solar System, and our galaxy.

Prof. Sergey Pulinets of Russian Space Systems then presented his work on the theoretical structure underlying the processes that generate earthquake precursors. Identifying this as the "Lithosphere-Atmosphere-Ionosphere Coupling Model" (LAIC, Figure 4), Pulinets detailed the relationships and mechanisms behind the various phenomena that can precede and even give forewarning of

10. See http://eng.ntsomz.ru/projects/earthquake/dodanews22062011 and http://eng.ntsomz.ru/projects/earthquake/dodanews07072011

Sergey Pulinets

an upcoming seismic event (precursors). These include infrared emissions (outgoing longwave radiation, OLR), earthquake clouds, and variations in the ionosphere, all of which, Pulinets argues, can result from the emissions of radioactive radon gas from an active fault preparing to give way. The ionizing effects of this lithospheric radon emission on the atmosphere, and the subsequent interaction of the atmosphere with the ionosphere, generates this detectable array of precursor signals, which can be used to forecast a seismic event.

These three presentations, along with two earlier ones on satellite- and ground-based methods for monitoring the conditions of the ionosphere linked with seismic activity, rounded off the discussion of seismic forecasting.

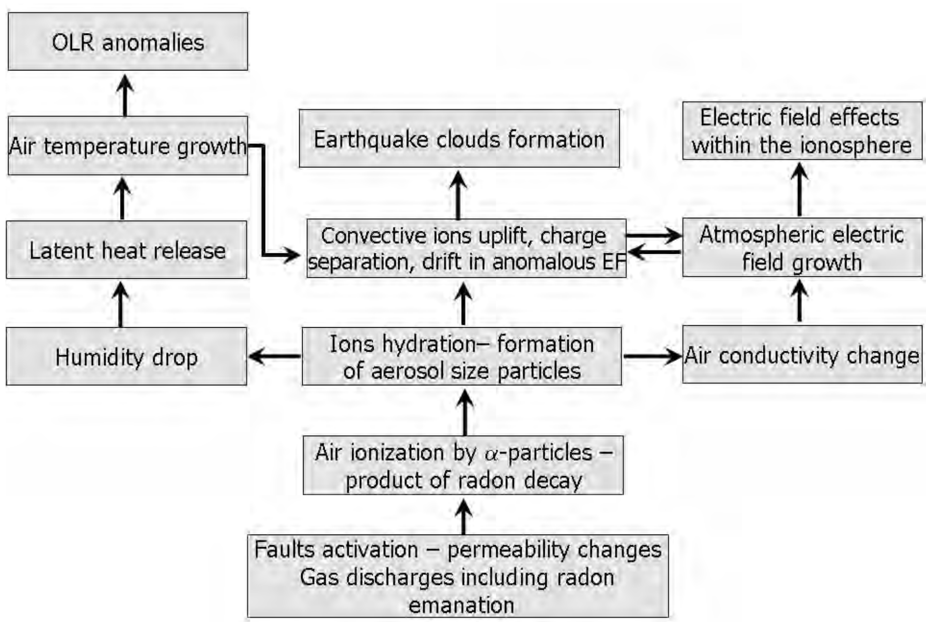
The objective discussed by Perminov and others, is to develop this capability and incorporate it as a key component of IGMASS, creating a new line of defense from earthquakes, volcanic eruptions, and tsunamis.

Planetary Defense

Another major component of planetary defense discussed at the conference was the early detection and defense against potentially hazardous asteroids and comets. Impacts have occurred throughout the history of the Earth, and the inevitability of future asteroid or comet impacts with the Earth has become an area of growing concern within scientific and defense circles internationally. An impact will happen at some point in the future (we just don't yet know when), and we do have the technology to defend the entire Earth from this threat—but only if we take the appropriate measures to, first, discover and track all the objects that could pose a threat, and, second, have a defense plan ready in the event we need to deflect one of these objects. Russia's own experience of the 1908 Tunguska event has instilled a keen interest in this subject within the country's scientific community (Figure 5).

This subject was taken up on the second day of the conference by Sabit S. Saitgarayev, a representative of one of Russia's key missile and rocket centers, the Academician V.P. Makeyev State Rocket Center.

Saitgarayev's presentation, "Proximity Echelon for Protection of the Earth Against Hazardous Space Objects as the First Stage of the System Development," opened with a summary of key background information on the range of asteroid and comet sizes, and how frequent and energetic impacts are for differently sized objects (impacts from larger objects are less frequent, but more damaging, while smaller objects hit the Earth more often, but are also less energetic). He then discussed early detection, saying that we must focus on the entire region between the orbit of Venus and the orbit of Mars, in attempting to identify the objects long before



Sergey Pulinets

Figure 4
LITHOSPHERE-ATMOSPHERE-IONOSPHERE COUPLING MODEL

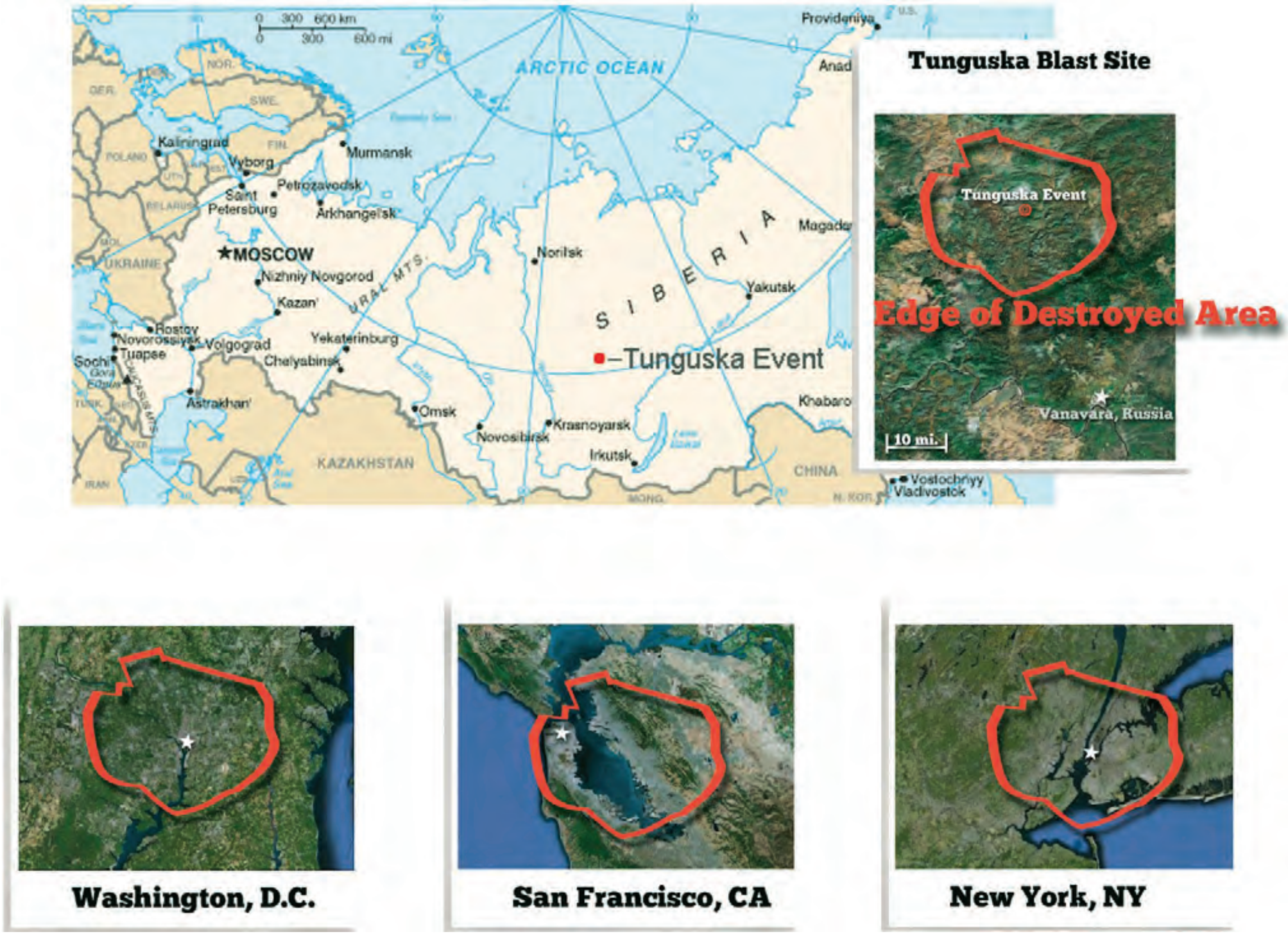


Figure 5
THE TUNGUSKA BLAST (1908) AND MODERN COMPARISONS
The Tunguska blast was an atmospheric explosion thought to be from a small asteroid or comet exploding as it entered the Earth's atmosphere at extremely high speed. Fortunately, this occurred over an uninhabited region of Siberia, as it leveled 830 square miles of trees. Any major metropolitan region today would be destroyed by an impact of this size.

they may hit the Earth. Saitgarayev concluded with a review of various methods that can be used to ensure that an incoming object does not impact the Earth, noting that his Center could produce the rocket system needed for such a mission.

While Saitgarayev's discussion remained within the realm of chemical rockets, another presenter provided a more forward-reaching option: the development of nuclear rockets. Anatoly S. Koroteyev of the Keldysh Research Center (a major unit of Roscosmos)[11] focused on "problems of space propulsion," emphasizing the need to develop nuclear systems in space. Summarizing the history of nuclear rockets, Koroteyev included a note about their possible applications for defense against asteroids and comets. The power density available with nuclear power allows for propulsion systems that can provide significantly more in-flight acceleration/deceleration (whereas chemical propulsion systems are limited to ballistic trajectories), improving the


Anatoly Koroteyev

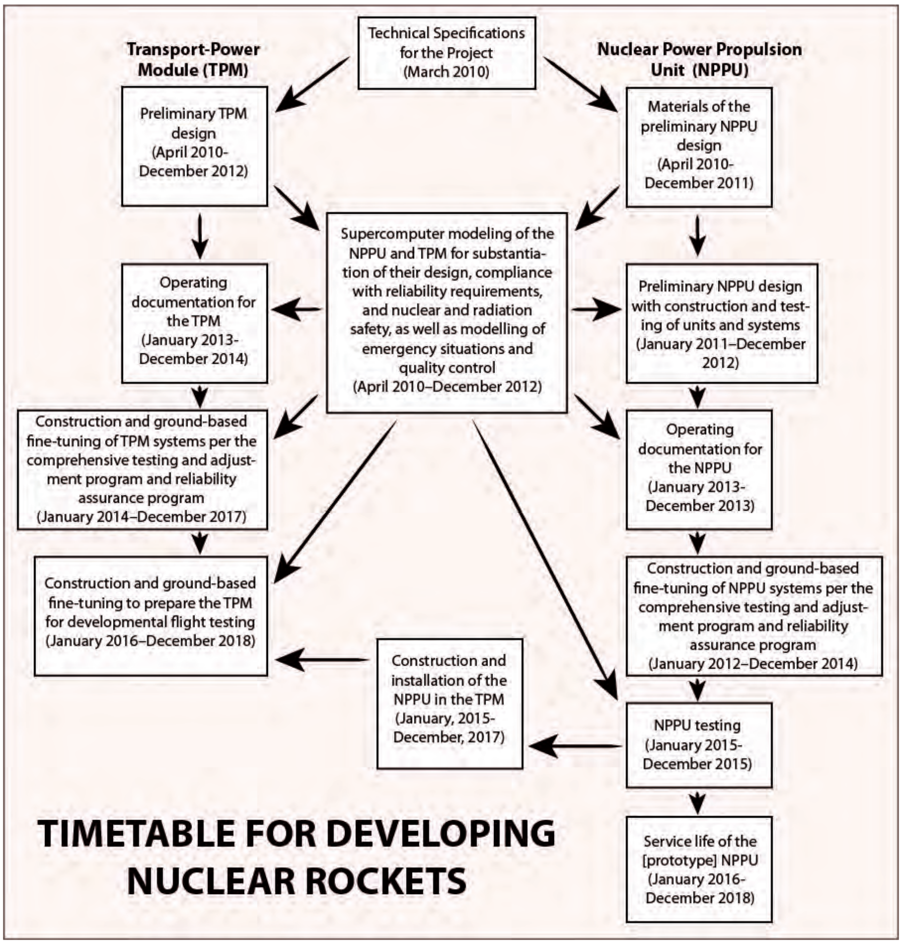
11. The Keldysh Research Center is a state-run facility under the direction of Roscosmos. It is a leading Russian organization in the field of rocket engine manufacturing and space power: developing, manufacturing, and testing rocket engines, space power systems, high-energy beam generators, and particle accelerators.

capability to alter the orbits of dangerous objects which may be on a collision course with Earth. Koroteyev noted that even the basic electricity requirements of satellite systems have been increasing logarithmically throughout the space age, and the limit of what chemical and solar power can provide is being reached, further making the case for nuclear. He ended with a brief overview the Russian government's perspective to develop new nuclear power systems in space, in which they plan on completing a new nuclear rocket by 2017 (Figure 6).

With these presentations focusing on the power and propulsion side, other presentations looked at examining man's observational capability in space. Specific proposals to expand our observational capability came from M.S. Chubey of the Pulkovo Observatory, near St. Petersburg. Titled "Orbital Stereoscopic Observatory," Chubey's proposal is to place two identical optical telescopes in orbit around the Sun, one that is always trailing behind the Earth, and another that is always ahead (see Figure 7; these are referred to as the Lagrange points 4 and 5, or "L4" and "L5").

The significant distance between L4 and L5 would provide a *stereoscopic* view of our Solar System and beyond, increasing our ability to judge distances (among other benefits), and improving our capability to see asteroids and comets, calculate their distance, and determine whether they are going to hit the Earth. The distances to nearby stars could also be directly calculated by measuring the parallax between the two different observatories.

M.L. Chubey



Anatoly S. Koroteyev

Figure 6

Toward a Global Revolution

The IGMASS conference demonstrated that there is progress being made in programs that can transform mankind's ability to defend itself from a wide array of threats. While some of this work is truly revolutionary, there are certain global realities that must be introduced here.

What became clear throughout the conference is not only the importance of a framework like IGMASS to forecast and respond to potential catastrophes on an international basis, but also the need for a larger political shift in order to achieve its full realization. Two points stood out:

First, underlying the three-day event was the reality of the collapsing global economic system, and the lack of financial, physical, and human resources required to actually achieve these absolutely necessary programs.

Second, the success of a system like IGMASS will only be fully realized through the integration of the scientific capabilities of all leading nations, something that will require the involvement of the United States. The capabilities of NASA, NOAA, and the U.S. military provide an in-depth capacity that could be integrated with Russia, China, and other nations to provide all mankind with the greatest possible defense from the threats discussed here. However, the current orientation of the United States toward Russia and China is a dangerously adversarial one.

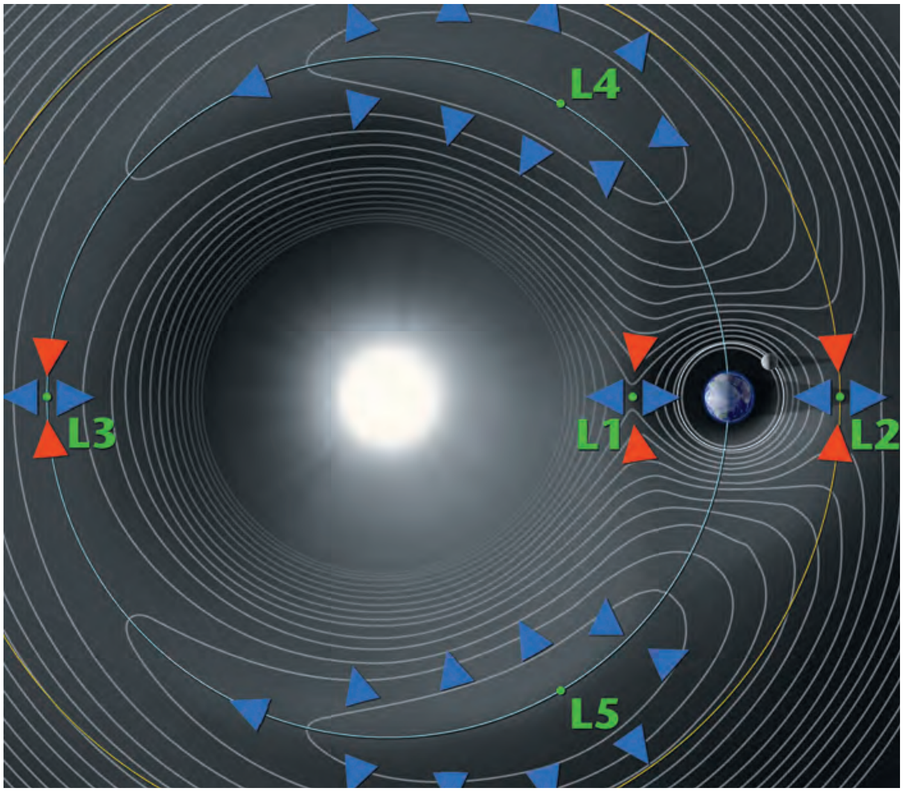
For both these reasons, the political-strategic framework initially proposed by LaRouche as the SDI of the 1980s—and the recent re-offer by Russia in the form of the SDE—becomes crucial. Without the global economic reforms being proposed by LaRouche,[12] and the strategic shift to top-down, science-driven cooperation among the United States, Russia, and China, the aims underlying the intention of IGMASS could never be fully realized.

To properly understand this challenge, we are forced to take a larger historical view of mankind's existence on Earth, and within the Solar System. What was referred to in the opening as a necessary *coming-of-age of mankind*, is the fundamental imperative underlying the scientific/technological challenges, but also the political, social, and cultural challenges now faced.

Can nations with different histories, different cultures, and different political structures unite in advanced scientific collaboration to overcome the challenges that face all mankind? Can leading nations overthrow the still-existing reigns of a millennia-old oligarchical system, currently centered in the global British Empire?

There is a basis for conquering these challenges, but it is only found in a scientific conception of the power that mankind actually expresses in the universe, as a uniquely creative species, and the future that mankind must act to create to ensure progress, defense, and development.

That is true planetary defense.



NASA

Figure 7
THE EARTH-SUN 'LAGRANGE POINTS'
The five Earth-Sun Lagrange points (bodies not to scale) are locations where the gravitational effects of the Earth and Sun reach a type of equilibrium. L4 and L5 are known as stable points, within which small bodies, such as small asteroids or man-made satellites, can maintain an orbit.

The issue becomes nothing less than man's self-realization of his role in the universe. As LaRouche continues to develop in his writings, the fundamental block that still holds people back from achieving this, is their false belief in their own sense perceptions. Human biology does not provide an "honest" representation of mankind's interaction with the universe. Sense perceptions are merely shadows. It is only through the higher capability of the human mind—something strictly not biological—that man can fulfill his active role of always continuing to create completely new and higher forms of action within the universe.

This is illustrated clearly by the concept of the IGMASS system, with the integration and expansion of multiple arrays of artificial sensory systems. Created by the unique powers of the human mind, these systems become integrated into the noetically extended artificial sensorium of man, increasing the power of the human species to understand and change the universe—an imperative for mankind at the present time of crisis.

12. See the LaRouchePAC report, "The Full Recovery Program for the United States," http://larouchepac.com/fullrecoveryplatform

Interview: Brent Barbee and Professor Bong Wie

SDE: Hypervelocity Asteroid Deflection

Say we discover a small to medium-sized asteroid (the majority of which we have yet to find), expected to impact the Earth in the next few years. Would we be able to stop it? Even utilizing the most powerful mitigation option available, thermonuclear explosives, the asteroid speeds involved can be extremely large, creating difficulties for existing navigation and control systems to target a small object. Staff writer Benjamin Deniston interviews Professor Bong Wie (Iowa State University) and Brent Barbee (NASA Goddard Space Flight Center) about their "Hypervelocity Asteroid Intercept Vehicle" concept at the Fall 2012 NASA Innovative Advanced Concepts (NIAC) symposium, held Nov. 14-15, 2012 in Virginia. NIAC examines early stage concepts that may lead to advanced and innovative space technologies critical for NASA missions in the next 10 to 100 years.

LPAC

Brent Barbee (center) and Professor Bong Wie (right) are interviewed by Benjamin Deniston at the Fall 2012 NASA Innovative Advanced Concepts (NIAC) symposium.

Brent Barbee: My name is Brent Barbee, and I'm a flight dynamics engineer at the NASA Goddard Space Flight Center. I also teach astrodynamics at the University of Maryland at College Park.

Bong Wie: And my name is Bong Wie. I'm the Vance Coffman Endowed Chair Professor of Aerospace Engineering at Iowa State University.

21st Century: To get started, maybe you could discuss the general concept of asteroid defense. First, why is it an area of concern? Why is it something we should be studying now, as an interest for the scientific community and the population generally?

Barbee: Well, asteroid defense is a very important topic because we know that our planet has been struck in the past by large and small impacters that have done damage to the ground. At present I think there are on the order of 170, 180 confirmed impact structures that have been found all over the world. Of course, most of our planet surface is covered with water and weathering and geological processes that have obscured the signs of impact, but we're discovering them; we know that they're there. So we know that it's a threat that is out there, that we're going to have to deal with.

So, it behooves us to be prepared ahead of time, so that we're not scrambling to slap together some sort of hastily prepared defense at the last moment, when we discover a threat. It's much, much better to have investigated the solution, tested it, done many dress rehearsals, so that we're very, very comfortable and very adept at doing it, when the day comes that we have to call upon those systems to stop an asteroid impact.

Because there are a few layers to the discussion, correct? There's observation, detection, finding all the possible threats. And then there's also the issue of mitigation, of doing defense against something that might be a threat to the Earth. Is that correct?

Barbee: That's right. Absolutely. In fact, you could say that planetary defense rests on a tripod of detection, characterization, and mitigation. So, if we have wonderful mitigation systems that are highly capable, but our detection capabilities are poor, then we will be well able to do something about the problem, but we won't know that it's coming. Whereas if we have wonderful detection systems, but no preparation for mitigation, we may very well see it coming, but be unable to act.

So, it's important to have both systems; and historically, up to this point, we've invested a lot more in detection, because it's something that we could do from the ground, using telescopes, and it's been a very successful effort, but now the time has come to begin appropriately, devoting appropriate resources, to the mitigation/preparedness problem as well.

Wie: If I may emphasize that for mitigating the impact threat of asteroids, detection is a necessary condition, but it's not sufficient. And we do need to develop mitigation techniques in order to be ready whenever needed.

The Asteroid Threat

Here we are at the NASA Advanced Innovative Concepts conference, and so what exactly brought you here to present something to this particular audience, relating to the asteroid threat?

Wie: We proposed a concept called Hypervelocity Asteroid Impact Vehicle, to the NIAC program, and this proposal was selected, because NASA felt that it is the next logical step to move forward to develop our own national protection system against the impact threat of asteroids. So, we are here to present our concept, and my Co-I [co-investigator] Barbee and myself, we were very pleased to receive constructive comments from our colleagues who are attending this conference.

Maybe you can describe why you need to do the work you're doing. Because most people might think, well, we'll just throw a bomb up there and hit it with a bomb—but as you presented earlier, it's not quite that simple. There's actually highly complex science involved in this question, this challenge. So maybe you could present a concept of what exactly you're bringing to the discussion here.

Barbee: Sure. The reason that it's not as simple as just throwing up a bomb—the reasons are multifold. On the one hand, you have the orbital mechanics, so orbital mechanics means that you can't just send the spacecraft to the asteroid for a rendezvous mission whenever you like. There are going to be certain times when you can launch, and have a low relative velocity, naturally, when you get to the target, and thereby effect rendezvous using a reasonable amount of propellant.

So, for our study, we're saying that we want to be ready to deal with short warning-time scenarios. We want to be able to launch essentially at just about any time. So that means that our system has to be designed to come in fast at the asteroid, [at a] high relative velocity at the time that we intercept the asteroid. So, we're not going to carry a propellant to slow down, because physics dictates that that amount of propellant would be huge.

So, our system is designed to come in at an excess of 5 kilometers per second—5, 10, 15, 20, up to 30 kilometers per second—relative velocity at impact. So, what that means is that we're coming at the asteroid really fast.

That's tens of thousands of miles per hour, correct?

Barbee: Oh yes, tens of thousands of miles per hour. So, I think, as a reference point, 7 kilometers per second is on the order of about 20,000 miles per hour—something like that, so yes, that's right. And as we're coming in, the asteroid starts off as this little tiny dot that the cameras on the spacecraft can just barely see, a few million kilometers away; and then, within a matter of hours, we're down to the last few minutes, and the last few seconds, and we cover hundreds of kilometers within a matter of a minute or so.

So, there's very little time for the spacecraft to react. So, we have to design robust on-board guidance, navigation, and control systems that can successfully hit that relatively small asteroid out in the huge volume of space, traveling at such high relative velocities.

What's more, is that in order to effectively disrupt the asteroid, our design calls for a two-body vehicle: an impacter and a follower. The impacter excavates a small crater, shallow crater, on the asteroid's surface, and then, within perhaps a millisecond after that crater is excavated, the follower spacecraft, which is just behind it, enters that shallow crater, and at that moment, must detonate the explosive device in order for it to be effective. If the explosive device were to strike the surface of the asteroid before detonating, it would be destroyed, and the mission would be a failure.

So, there are some very precise timing [issues] and a key sequence of events that will have to happen at hypervelocity, driven by robust, cutting-edge new sensor technology, to make all of that happen, and make it happen in a reliable way, so that we know that we can build five, six, seven of these systems, and deploy them, and have high confidence that they would work as designed.

Hyper-Fast Speeds

So, you're talking about just incredibly fast speeds and incredibly accurate timing, to be able to have this go off, in just the right fashion; and obviously, this is something where, if we were to encounter a situation where we needed this to work, we would need it to work! We couldn't—we would need to make sure this is 100% effective, and have the effect we need.

Barbee: These relative velocities that we're talking about are beyond what we can currently test in terrestrial laboratories. I mean, there are facilities with rail guns and light-gas guns that can get up to the range of 3 to 5 kilometers per second, maybe a little bit more.

But for the regime of speed that we're talking about, it's a very unexplored region. What happens to the materials that the spacecraft is made of? What are the consequences of those materials' effects on the payload that we're trying to deliver to the target? There's a whole host of issues that we have to research. The materials science, the structural design, the hypervelocity-impact physics, and of course, the robust guidance navigation control happening on a very, very short, almost infinitessimal time frame.

So, there are several aspects to this research that are really pushing the boundaries of what's been done.

Wie: But to give the feeling of that high speed, let's say 10 kilometer per second, or even 11 kilometer per second, on someone flying an airplane, that will be more like landing an airplane from a cruising altitude of 36,000 feet, which is about 11 kilometer altitude, in one second, and landing on the runway. That is the kind of speed we don't usually talk about for airplanes. But in space, that is a common speed.

So, currently, we do have guidance navigation-control technology which can provide a reliable precision of an impacter against asteroids. But we have not demonstrated our capability against a small target—50-meter or 100-meter small size. I mean, that is our research goal. The goal is to develop flight-proven technology to be ready to be used, for a small 50-meter, 100-meter target, with a very short warning time.

I know when it comes to a discussion of mitigation, there's a complex number of scenarios and questions. You mentioned that you are specifically looking at short warning times, because the idea is, if you have a longer warning time, there's an array of methods you might be able to use. You might be able to kind of bump it, or impact it with a non-explosive device. You might be able to pull on it gravitationally, or by various other means. But you're focusing on a very specific scenario, where we might only have months, in the range of months, warning time, right?

Barbee: Even up to several years. Really, anything less than ten years falls into the range of scenarios where you would need to use some kind of a nuclear solution. The NRC [Nuclear Research Council] report that was released several years ago, sort of identified that range of warning time, from ten years down to zero, essentially, as being the regime in which you need to have some kind of a nuclear solution. Because of the energies involved.

And that's why I want to ask, just to illustrate for people: Because when you're talking about the energies needed to have an effect on these bodies—you're talking about mountains, basically, mountain-sized rocks and debris flying around in space—the energy density you get with nuclear and thermonuclear capabilities is just orders of magnitude more than you get otherwise. Is that correct?

Wie: Yes, that's correct. Also, I'd like to emphasize that we don't have correct definitions of a short warning time. Everyone has a different time scale. So, as we said, even a ten-year warning time, we consider short. So let's assume that we have ten years lead time, but if it takes nine years to make a decision for the launch, then we have only one year engineering lead time, that is not sufficient.

So that's the situation right now. We don't have a clear definition of what do you mean by warning time. Does it include political decision time? Or do we have a system to be launched right now? Do we have to find a launch vehicle, or do we need to design a satellite? So, that is an open issue to be further studied, to be discussed.

International Collaboration

I wonder if you also could speak to the idea of international collaboration, because obviously, the first thing that comes up with this, is—these asteroids, they don't distinguish between NATO countries and non-NATO countries, or which economic bloc it's going to impact somewhere on the Earth. This is a global threat that transcends a lot of national boundaries, obviously.

You know, we're interested in collaboration with, especially Russia and China, for example. This should be an effort where we should be pooling the scientific capabilities of the best nations of the world, and I was wondering if you had any thoughts on the importance of that aspect of the threat.

Barbee: Well, planetary defense, for all the reasons you just said, would be a wonderful thing for all the people of the world to cooperate in. That would be fantastic. But until that day comes, there are going to be some pretty thorny issues that have to be dealt with.

For example, if you have an object whose diameter is 1 kilometer or larger, when asteroids get to be that big, or bigger than that, that's when you really have the threat of global consequences from the impact. For things smaller than that—when you're talking about a several-hundred-meter asteroid, maybe a 100-meter, 50-meter asteroid—the effects of those impacts, while still devastating, are on a more localized scale. We'll know ahead of time, when we've spotted the asteroid coming, what are the possible impact locations on the Earth. And so, if it's going to be impacting one region or one country, and it's only going to affect them, then who's responsible for building and deploying and managing the deflection mission, if that country's not capable of doing it themselves?

Those are the kinds of questions that are going to be asked.

And then there's the question of liability. Who's liable if the effort fails, or if it makes the problem worse than it was to begin with? So, the questions of responsibility and liability really rise to the top, when you're talking about this small several-hundred-meter, down to maybe 50-meter, asteroid size in range, which is difficult to deal with, but it's something that really has to be thought about, because the smaller asteroids, between 50 and several hundred meters in size, are more numerous than the very large kilometer-sized and larger asteroids.

So, it's much more likely that, within any given time frame, we're going to be faced with the threat by one of the smaller asteroids than one of the very, very large ones. So, it's something that we should... I don't know what the answer is, but these are some of the questions we need to start thinking about for the first steps in international collaboration.

The Big Picture

As a last question, let's take it to the big picture. Say, we live on this planet. If you look at it on the scale of the Solar System, it's a relatively small location. Our Solar System is located in this entire galactic system. Here, we've got records of the history of life coming and going on this planet, mass extinctions, major extinctions; some we think are related to asteroid impacts, others maybe to other events—global climate changes, maybe supernovae, all kinds of things that go on in our environment that tend to be in an area that's, say, above the heads of most of the general population.

But it seems like taking on this issue has some rather profound philosophical, cultural implications for what this means for mankind, to actually consciously take on a challenge like that. And I wanted to know if you wanted to speak to any of these bigger-issue pictures that are related, when you bring in questions of tackling these types of challenges.

Wie: Yes, I agree with you that there are many other natural disasters that we cannot do anything about, to prevent those events, but the impact threat by asteroids can be detected in advance, and probably such an impact threat can be prevented, because we have the technology. But the technology is not quite ready. And we need to develop those technologies which can be used when they are needed, at the right time, in the future.

Any last comments?

Barbee: Well, it's true that asteroid impact is probably one of *the* most serious natural disasters that is, in principle at least, preventable. And so, it seems to me that for any species that's going to survive for a very long period of time, such a species would almost certainly have to make the deliberate choice to learn to protect itself from any extinction-level event, and that, if we, as human beings, are able to make that jump, and make that decision, and make that choice, that bodes really well for long-term survival.

Not just because of stopping the asteroid from hitting, but for what that means about us as a people, and us as a species, that we're able to have the forethought and be willing to behave cooperatively towards that end—that, in and of itself, regardless of the technology to deflect the asteroid, that decision, that choice, means a lot for our future.

Interview: Gen. Vladimir Popovkin

Space Exploration And Physics Breakthroughs

Benjamin Deniston and Peter Martinson of LaRouchePAC TV interviewed Gen. Vladimir Popovkin (ret.), head of the Russian Federal Space Agency (Roscosmos) on May 22, 2012 at the Global Space Exploration conference in Washington, D.C. General Popovkin's remarks were translated from Russian by Executive Intelligence Review (EIR).

NASA/Carla Cioffi

At the Global Space Exploration Conference, Roscosmos head Vladimir Popovkin (inset) laid out Russia's ambitious plans for space exploration, which, he emphasized, require international cooperation. His presentation was in stark contrast to the doom and gloom of other speakers.

LPAC-TV

Ben Deniston: In late April, RIA Novosti reported that the deputy head of Roscosmos had spoken of a proposal to create a new Russian federal program to deal with the threats of potentially hazardous asteroids and comets. Could you speak to that proposal? It was also that the Russian Academy of Sciences would help coordinate that effort. What's the status of the current discussion?

Popovkin: There are such plans, that is true. But at this time we are not so much preparing to combat the threats; rather, at this stage, we want to evaluate these threats and establish a system of monitoring objects in space. We are drawing not only on the resources which Roscosmos itself is developing today, but also those of the Russian Ministry of Defense and the Academy of Sciences. And the purpose is precisely to begin to monitor outer space, and space objects.

Such a monitoring system will then enable us, to the extent possible, to combat, or counteract, some threats from space. But first we need to collect the statistics and make an assessment of the objective situation. Does something present a threat to us? If it does threaten us, then how great is the threat? If there is some degree of a threat, then when and with what probability? And after that, a decision can be made. This is what my deputy, Mr. Davydov, was talking about, and this is what has been supported by the Russian Academy of Sciences.

Deniston: Deputy Prime Minister Dmitri Rogozin has also spoken about the idea of cooperation with the United States on this issue. If we had the optimal level of international cooperation, the optimal level of interaction between the United States and Russia, what would you like to see in terms of cooperation to address this?

When Dmitri Olegovich Rogozin spoke about this, he said that cooperation in this area would be a lot more useful and effective than building the European Ballistic Missile Defense System, the intended purpose of which Russia still doesn't accept, particularly when it comes to the deployment of surveillance and strike systems. And precisely from this standpoint, if this can be organized, it would be much more effective and better to do it. To speak more specifically, what was proposed was to involve all the available optics—regardless of where they are located or what agency they belong to—that are being used to study and investigate space, and have them operate under some kind of single plan or concept, in order to achieve the best possible monitoring of all objects in space.

Deniston: Mankind has not set foot on another planetary body since the early 1970s. Earlier you spoke to Russia's vision to change that, to get mankind to the Moon. I'm hoping you can speak to that further and lay out what Russia's perspective is for returning mankind to the Moon.

Well, human feet have already taken steps on the Moon, and there is no point in just repeating what was done 40 years ago. Therefore I was talking about something a bit different. I said that human knowledge about the Moon today is considerably greater than 40 years ago. The possibilities for lunar research are now completely different, using the technologies produced through scientific and technological progress during those 40 years. And the first area, as I already mentioned, is research on the Moon itself, and on what there is on the Moon: including the areas where water has been detected, in the south and north polar regions of the Moon.

LPAC-TV

LPAC's Ben Deniston interviews Roscosmos Director Gen. Vladimir Popovkin (right) at the Global Space Exploration Conference on May 22, 2012.

Secondly, if we take into account the particular features of the Moon, first and foremost the fact that it does not have an atmosphere, the Moon could become an ideal platform on which to position various telescopes, both optical and radio telescopes, for astronomical research, research on distant stars. What the participation of people looks like will be determined by whether we can now design such technologies to be completely automated, or if they will need to be serviced by human beings. Whether or not man needs to walk on the Moon or not will depend on that. That's what I was trying to say in my speech.

Peter Martinson: In the United States we had a program called NERVA, which was a nuclear thermal rocket program back in the 1970s. Are there any programs being carried out now in Russia for specifically using nuclear reactors to propel thrust, for fission, nuclear fusion rocket propulsion, or even matter/anti-matter rockets?

Yes, we are moving into work on a gigawatt-class nuclear-powered engine. And the development of such an engine is dictated by the requirements of exploring the remote planets. It's too early to report on any results. But it is my deep conviction that if we want to explore deep space, then, first of all, theoretical physics needs to advance quite a bit, because based on the laws of motion we know today, and of course the power units we have now, we won't get very far.

And if you can understand such things as the physics of black holes, or the compression of stars, or movement through worm holes—there are a great many of these theoretical things that theoretical physics today is investigating—I think that there ought to be some discoveries there which will allow us to travel based on completely different principles. These are all still profoundly theoretical matters, but at some point there should be demand for them.

Interview: Dr. Claudio Maccone

Protecting Mankind From Extra-Terrestrial Threats

*At the Astrobiology Science Conference 2012, "Exploring Life: Past and Present, Near and Far," in Atlanta on April 18, Oyang Teng of the LPAC Basement Research Team interviewed Dr. Claudio Maccone, Technical Director of the International Academy of Astronautics, on humanity's current vulnerability to extra-terrestrial threats such as asteroids, comets, and supernovas, and the needed international collaboration to overcome such dangers. Dr. Maccone is the author of "*Deep Space Flight and Communications*" (2009).*

The interview took place following Dr. Maccone's presentation at the conference on humanity's lack of preparedness for an asteroid or cometary impact. A video of the interview can be seen at http://larouchepac.com/basement.

U.S. Department of Energy

"We need to make a real leap forward," Dr. Maccone said, to defend the Earth from an impact by an asteroid or comet, "that would cause millions, if not billions, of casualties."

Oyang Teng: Dr. Maccone, I wanted to start by asking you to summarize—you started your presentation saying, the punchline is, we're not prepared—but maybe you could say briefly what the nature of, first the short-term threat, or maybe the immedidate threat as you see it, of an impact event on the Earth.

Claudio Maccone: Well, the situation is pretty clear nowadays. We know that there are about over 300,000 rocks in the Solar System, basically asteroids, but also big, dead comets, or comets, or whatever. And the vast majority are rocks smaller than 1 kilometer [in diameter]. Now, this means that it is not easy to see them with telescopes. Nowadays, we can see them because we have automatic systems of telescopes taking care of the orbits immediately—as soon as they take the digital picture of the part of the sky with the asteroid—they can immediately compute the orbit, and find out whether these are old, known objects, or new, unknown objects.

Anyway, there are so many small rocks, that really hoping that none will ever hit the Earth is crazy. So, we must be prepared for that. And actually, there is a JPL [Jet Propulsion Laboratory] website that everybody can see—it's public access, not secret—listing a set of asteroids or near-Earth objects that have a certain, higher-than-zero probability of hitting the Earth sometime in the future, or anyway coming close to the Earth, sometime in the future, in a century or so.

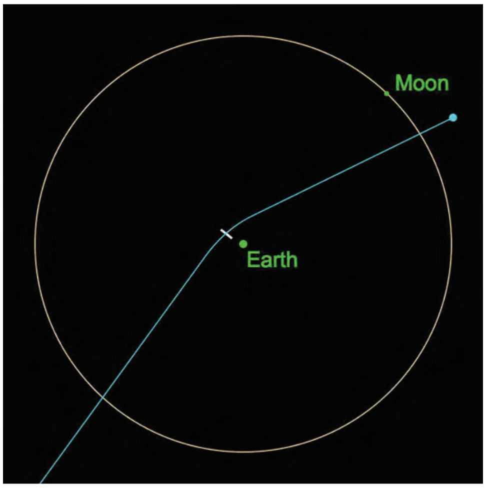
So this is the first basic fact that I would like to point out.

There is a second fact. The orbits of these bodies are not precisely known. Just to put it in simple terms, students at university learn that if you have an ellipse, which is the orbit of an asteroid around the Sun, you must specify *six* parameters in order to have this ellipse precisely located in time and space.

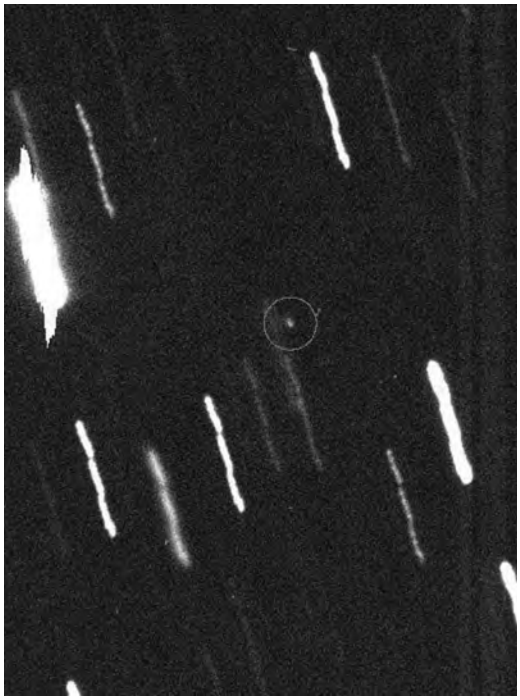
Now, these parameters are totally arbitrary because there are the so-called integration constants of three differential equations of the second order—a Newtonian equation. So there are six parameters for each asteroid. Absolutely arbitrary.

Now, the point is that, we do not know *exactly* what the numbers that speak to these parameters are. Actually, we derive likely values of these numbers from the orbits of some 30 bodies or so, the most massive bodies in the Solar System.

So, let me put it in clear terms. The 30 most massive bodies in the Solar System have orbits that can be computed by today's computers, but all the rest, which means 300,000, 400,000, have to be, so to say, described on the basis of the



The danger to humanity posed by an asteroid or comet, is "a really serious problem," Maccone stated. Shown: a schematic of the possible trajectory of the near-Earth asteroid Apophis in 2029; a NASA image of Apophis (circled) in space (right).



NASA/JPL

first 30 bodies; and so there are certainly uncertainties in the values of these parameters.

Now, this is a really serious problem, because we do not know exactly whether any one of these bodies is going to hit the Earth or not.

We Need a Real Leap Forward

Is it a question then of getting more ground-based or space-based instrumentation to track these objects, or can we do it with the existing tracking that we have, but we just need to put more resources behind it?

Well, certainly, the tracking must be done. There is no question about it. And also, the discovery of more objects that we still don't know about has to be done. But this is not enough. We need better computers, and I'm hoping that when the quantum computer will become effective, it can solve the problem. But this is not the case yet.

But apart from all this, which is essentially a mathematical game, we need to make a real leap forward. And this is to prepare space missions capable of going out into space, away from the Earth, as much away as possible, hitting the asteroid, moving that body away from its collision course against the Earth, and so, really, literally, rescue the Earth from an impact that would cause *millions*, if not *billions*, of casualties.

If it weren't an issue of budgetary constraints right now, what, in your view, would be the next step, that would have to be taken, concrete steps, to do exactly that? What sorts of missions are we talking about?

Okay, now let me first refer to the United States, since we are in the United States. But of course, this is a problem that affects the whole of humanity. Well, in the United States, before 2011, which is one year ago, NASA was planning to build two launchers, called Ares I and Ares V. And I was part of a study in 2007, led by NASA, about this thing; essentially, we had to make an assumption, just to give you an idea about what we did.

We hoped that we could have a ten-year lead time, meaning we would come to know ten years in advance whether an asteroid was going to hit or not. So, on the basis of this, then we would have planned two different space missions. The first mission to be carried forward by Ares I was a survey mission, sending the probe around the asteroid, picking up pictures, finding the mass, the shape, rotation, whatever. After that, the second mission would have arrived, launched by Ares V, and that would have been a much more effective thing, shooting six projectiles, 1.5 tons each, against the asteroid, in order to move it away from the collision course.

If this was not enough, then, we also considered the possiblity of using nuclear weapons. Now I am completely aware that nuclear weapons in space are not loved by anyone, but especially not by the ecologists. I am quite aware of this. But the point is simply that, if the body is too massive, and the six projectiles that I just mentioned are not enough to move it away, there is no other way than using a nuclear explosion, not on the body itself, but at an optimal distance from the body, so that the gamma rays produced during the explosion, *push* the asteroid away, because of the momentum of the radio waves, of the gamma rays, and so on. So this is the technique, basically.

Now, the point is that, just one year ago, your President Obama decided to give up these two rockets, Ares I and Ares V, and replace them with a single transportation system. So this, in plain words, means that we have to redo a whole lot of calculations, because we are using different launches. And, at the moment, no such system is in existence at all, so if we discover that there is something on a collision course with the Earth, at the moment, we are unable to do anything against it.

Russia's Strategic Defense of Earth

You mentioned the importance of the role, in this case, of three major players. One, is the international scientific community; two, is the space agencies, such as NASA, ESA [European Space Agency], etc.; and three, is the military, because of their organizational capabilities, and their access to weapons. So I'm wondering, the one proposal that's come out in the last year from the Russian government, by the name of the Strategic Defense of Earth, is a transformation of what was once a military defense project for missile defense on Earth, to a defense against these extra-terrestrial impacts. Do you think that that is a useful model for the kind of program approach to deal with this?

NASA/MSFC

President Obama has eliminated the program for the Ares I and Ares V rockets, that could have been part of a defense of Earth. Now, said Maccone, "if we discover that there is something on a collision course with the Earth, at the moment, we are unable to do anything against it." Shown: an artist's concept of the Ares-I and larger Ares-V rockets.

It is a useful model, and at least it is something better than we have in the West—because we have *nothing* at the moment. So, we should really pay careful attention to what the Russians are doing, because they were good enough—let me use these words—to convert a system that had been designed during the Cold War times, from a defense against American missiles, to defense against asteroids and comets. So they are setting an example. And this means that international cooperation in this field is absolutely useful, not to say, indispensable.

Now apart from the Russians, of course, the Europeans are considering the problem seriously. I am aware that a few years ago, a new group of people taking care of planetary defense in Europe was created. But of course, we also expect other contributions, for instance, from China; for instance, from India; for instance, from Japan, and so on.

So, the bottom line is that the organization to which I belong, and of which I am a director, the International Academy of Astronautics, organizes worldwide conferences about planetary defense, once every two years. Last year, it was held in Romania, with attendees from all over the world. Next year, it will be hosted by NASA in Flagstaff [Arizona], with a visit, of course, to the meteor crater nearby.

And so, I would encourage young people, who have no idea about planetary defense, or anyway, want to get involved with this kind of problem, for the benefit of the whole of humankind, to attend this conference. Because in these meetings, you really meet, not only the experts, but also the decision-makers, those who have the power to transform projects into reality. So, my suggestion is that if you are interested in that, you should show up there.

Galactic Threats

On the nature of the threats: We know that we are not simply dealing with asteroids and comets, but that we live in a galaxy that is constantly evolving, and we know, still, very little about it. Could you speak to what you think are the broader, longer-term questions in terms of planetary defense, and how we, the human species, has to manifest itself in terms of our activity in space?

Sure. There are certainly other terrible threats to life on a small planet, such as we are. Let me just mention some.

First of all, I would mention supernova or nova explosions. These are simply explosions of stars that have come to the end of their life because they have nothing to burn any more, no more fuel to burn. Now these we know do occur: for instance, the Kepler supernova in 1604. They explode everywhere in the galaxy, so if there is one exploding next to us, we can only keep our fingers crossed. Because if the distance is something greater than 3,000 light years, we might possibly survive. If it is not, then, I cannot see any hope for us. We will be literally fried. And there is no way to shield humanity against that, as far as I can see, at least for the moment. So this is certainly a danger.

Next: There are other dangers. For instance, if you have a binary star, that is, two stars revolving around each oth-

NASA

Among the "terrible threats to life" on our small planet, are supernova or nova explosions. "They explode everywhere in the galaxy, so if there is one exploding next to us, we can only keep our fingers crossed," Maccone said. Shown: The red circle in the upper left, near the constellation Cassiopeia, is SN 1572, or the Tycho supernova, about 3,500 light years away.

er, and if you have a planetary system around each of these stars, that is, planets revolving around each of these stars, numeric simulation plainly shows that, if this goes on for ages, millions or billions of years, the planets may, sometimes, jump from orbiting around one star, to orbiting around the other star, because the gravitational pull brings them into such a condition.

Now the point is that, in the end, all planets in such a double system, are going to be ejected. And this is awful! Because it means that, in the galaxy, there are a number of so-called "rogue planets," which are precisely that. Planets that have been ejected by gravitational reason. So they just travel along a straight line until they find some mass that deflects them. And just suppose, unfortunately, that one such rogue planet is coming toward the Solar System. I don't mean it's going to hit the Sun, or something like that. It could pass close enough. Well, that would disrupt the gravitational stability of the Solar System.

So the orbit of the Earth, rather than being nearly a circle, could become an ellipse again. And you can easily imagine the consequences on humanity living on this planet.

So, that is a terrible threat, and again, at the moment, I cannot see any way we can imagine to get rid of that, except for carefully watching the sky as much as possible in advance. And, if such a body arrives, try to disrupt it, you know, to shoot nuclear weapons against that, in order to at least reduce the mass that would deflect the Earth from its orbit.

The 'Extraterrestrial Imperative'

My last question is, you ended your talk saying, at the moment, given where we are, we're really still as good as the dinosaurs. And it is the case that, thinking about this planetary defense, forces you to think about evolutionary times. But if we project forward, there is a term that was coined by a space philospher and scientist, Krafft Ehricke, he called it the "Extraterrestrial Imperative." That humanity has an extraterrestrial imperative which is really an evolutionary imperative to not only leave the Earth, in the same way a baby has to leave the womb, but to develop the Solar System and beyond. And that this is actually a cultural, economic, and scientific imperative.

So, I would like you to speak to your thoughts on this idea, and maybe where you see humanity in the next 50 years, or 100 years.

Thank you. Well, you are touching a subject that I really love. Actually, I wrote a book called *Deep Space Flight and Communications*. Now, "deep space flight" means what it really is: going to the edge of the Solar System, and possibly, beyond.

Now, at the moment, unfortunately, we do not have the technical capabilities of planning for a starship that would leave the Solar System and reach even the closest stellar system, which is Alpha Centauri, at 4.37 light years away. I am glad to say, that in the last year, DARPA [Defense Advanced Research Projects Agency], the military advanced research project, and NASA Ames Research Center, organized a conference held in Orlando [Florida] last year in the Fall, gathering all the scientists who are trying to solve this problem of how to get to the nearest stars.

We do not have the solution, but at least, we came to know each other. Serious proposals were discussed, for instance, anti-matter proposals—I'm just mentioning one, the one that I like most. But nobody really knows which one could be selected. Anyway, this doesn't really matter.

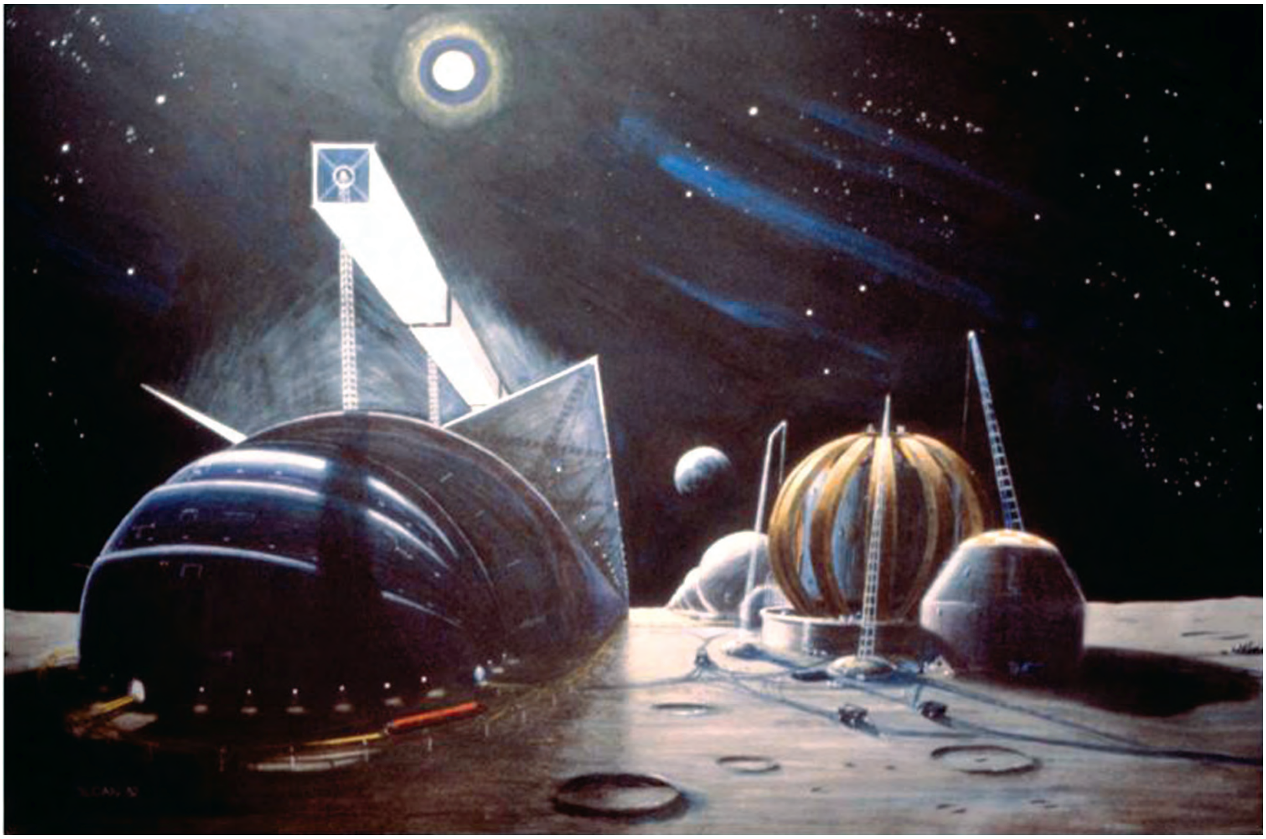
At the moment, at last, NASA and DARPA realize that this has to be studied, even if we are in financial troubles that we know about.

So, for the future generations, I can only encourage more interest in these kinds of things. The time will come when we will be able to reach at least the nearest stars, and that could mean the rescue of humankind from certain death in case an asteroid or supernova or a rogue planet destroys life on Earth.

Okay, well, that's a note of optimism!

Thank you very much.

Thank you Dr. Maccone. And I guess we'd better get started.



Fusion/Christopher Sloan

Selenopolis, Krafft Ehricke's city on the Moon, will establish mankind's first polyglobal civilization. Not an austere outpost, but a modern urban city, housing thousands, Selenopolis will be powered by fusion power plants, seen under construction on the right. It will represent a critical step in the economic integration of cislunar space with the Earth.

Why Mankind Has An Extraterrestrial Imperative

by Marsha Freeman

At the current moment, mankind is facing a series of existential threats. Some are immediate, including the absolute devolution of the human species, where policies that have created a lack of food, of medical intervention, of energy resources, and the other basic necessities of life, threaten to bestialize the world's citizens, and could propel us toward nuclear war. Others are intermittent, to include extreme weather, volcanic eruptions, and other natural catastrophes. Some are unavoidable, such as the eventual depletion of the Earth's currently-defined stock of natural resources. And some could, at any time, threaten the survival of the entire planet's population, as we travel through the Solar System's minefield of asteroids and comets. Ultimately, the Sun itself will evolve so as to make life impossible on the Earth.

German-born visionary, Krafft Ehricke, proposed decades ago that mankind, unlike any other species, using his "power of reason" and "the moral law within himself," could meet and overcome these challenges. Life on Earth, he stated, was not "local," but a cosmic phenomenon, enabled, most directly, by the largesse of our Sun. Life on Earth will grow and develop, he explained, only if mankind's theater of activity is also cosmic.

To Krafft Ehricke, space was not a place, a program, or a specific set of missions, but rather, the pathway to the future, created by man's intervention into, and development of, nature.

Over the past century, various visionary thinkers have put forward imaginative plans for what mankind could do in space. But Krafft Ehricke described this thrust in to space as an "imperative," because for mankind to grow and develop, there is no alternative.

> ## Three Fundamental Laws of Astronautics
>
> ### First Law
>
> Nobody and nothing under the natural laws of this universe impose any limitations on man except man himself.
>
> ### Second Law
>
> No only the Earth, but the entire Solar System, and as much of the universe as he can reach under the laws of nature, are man's rightful field of activity.
>
> ### Third Law
>
> By expanding through the universe, man fulfills his destiny as an element of life, endowed with the power of reason and the wisdom of the moral law within himself.

An "Open" Versus A "Closed" World

Krafft Ehricke was present at the opening of the space age, on October 3, 1942, when a German A-4 rocket, for the first time in human history, pierced the upper boundary of the atmosphere, and skimmed the edge of space. By the 1950s, he had no doubt that the technology for space flight would be successfully developed. What concerned Krafft Ehricke was whether the level of cultural maturity of mankind would meet the challenge of the extraterrestrial imperative. He recognized that throughout history, an opposing view to his, and that of the Renaissance, periodically gained dominance in the affairs of men. In 1957, just months before the Soviet launch of Sputnik would signal the true start of the Space Age, Krafft Ehricke formulated his Three Laws of Astronautics (see box) to set the philosophical guidelines for this next age in mankind's evolution.

By the mid-1960s, he warned that "no-growth'' policies, being massively promoted by London's Tavistock Institute, what would become the Club of Rome, and their "environmentalist" off-shoots, would pose a threat to the very existence of mankind.

A schematic summary of Krafft Ehricke's conception of the pathways open to mankind, is presented in his 1971 graphic, seen in Figure 1. Philosophically growth-oriented world policies, based on the view that the Earth is not a "closed" system, but part of an "open world" encompassing most immediately the Solar System and eventually, all of the cosmos, would lead to overcoming limitations through the application of science and technology. The lower half of the diagram, the "no-growth" pathway, leads to stagnation and regression, geo-economic and geopolitical power politics, extreme poverty, mass starvation, epidemic mortality waves, wars, nuclear war, revolutions, and ecological crises. Or just about what we have come to today, after suffering four decades of the anti-human, anti-growth policies about which Krafft Ehricke had warned.

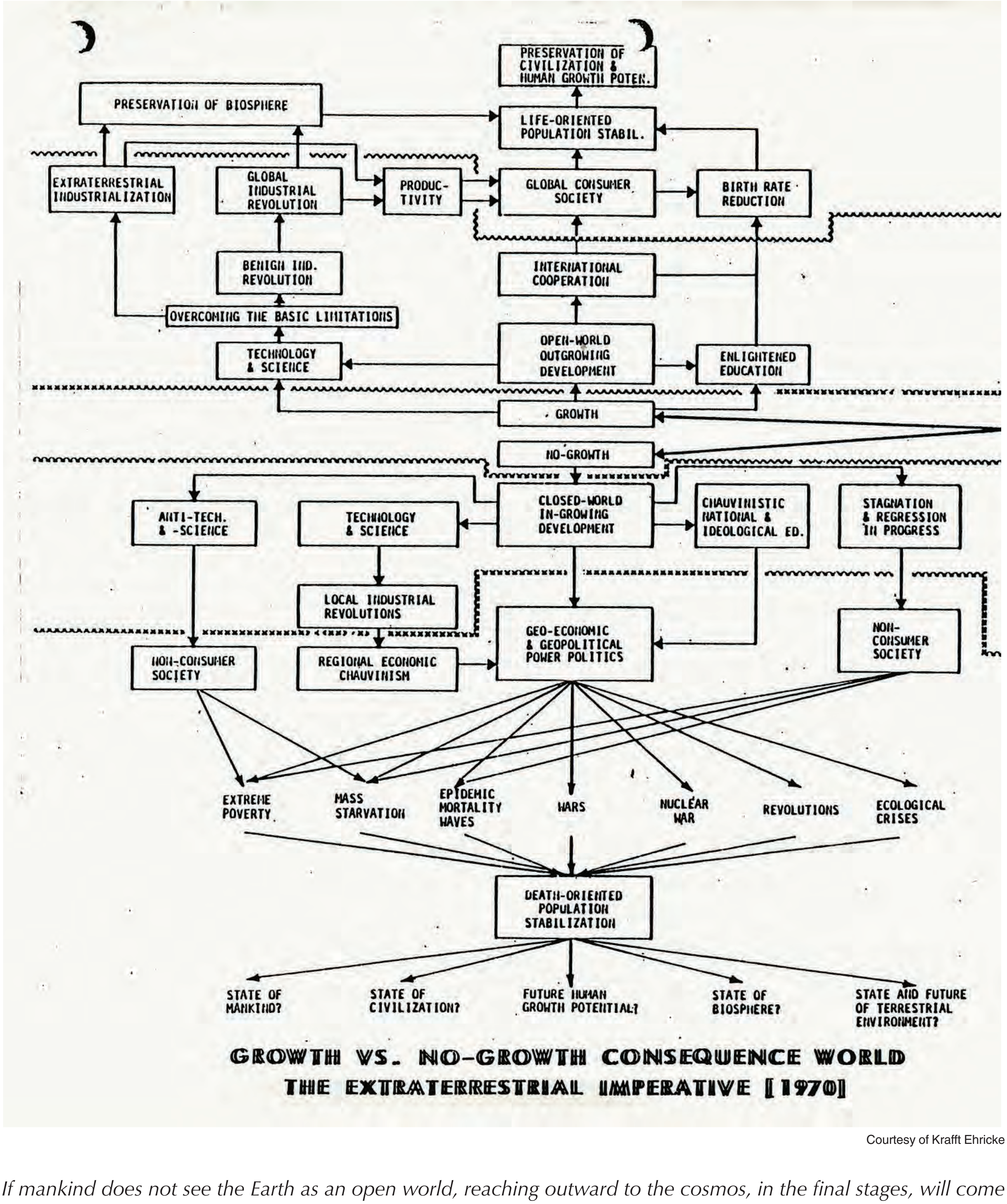
To take this message to a broad, and non-technical audience, in 1972, Krafft Ehricke composed an opinion piece for the *New York Times*, in which he states: "If we value what has been achieved since the Renaissance, technology must advance. Technology yields industry and production, providing more than [a] minimum-survival standard. Technology gives us access to nature, the infinitesimal and the infinite, stretching the human mind and making it grow in a million dimensions. Renouncing this means to cease growing. To cease growing means to make a grim past the future's only option."

Until now, Krafft Ehricke explained, mankind has been limited to a two-dimensional existence-- philosophically, as well as physically, chained to the surface of the Earth. He must progress to create a three-dimensional civilization, to encompass all that he can reach, as technological advances extend our access to the cosmos. With the Solar System at our fingertips, how could one claim that there are "limits to growth?"

The Integration of Cislunar Space

So far, mankind has merely dipped his toes in to what President Kennedy described as "this new ocean" of space, harking back to the first age of exploration. What Krafft Ehricke imagined the infrastructure in near-Earth space would encompass is reflected in the Russian IGMASS proposal, described in this issue. But to Krafft Ehricke virtually every realm of activity that is carried out in two dimensions on Earth, should be engaged in from the third dimension, exploiting the unique characteristics, first, of Earth-orbital space. In fact, in his view, the extraterrestrial imperative required the integration of life on Earth with the life we place in space. This includes global observations of Earth, navigational aids, global communications, and other familiar applica-

Figure I



Courtesy of Krafft Ehricke

If mankind does not see the Earth as an open world, reaching outward to the cosmos, in the final stages, will come starvation, extreme poverty, and wars. This graphic representation of the consequences of a "no-growth" world was developed in 1971 by Krafft Ehricke to accompany his manuscript, "The Extraterrestrial Imperative."

Courtesy of Krafft Ehricke

On September 26, 1966, Krafft Ehricke joined veteran CBS reporter, Walter Cronkite, for a television studio presentation on his future concepts for space exploration. Here, Krafft Ehricke (left) is explaining a model of his orbital hospital.

tions, such as weather forecasting. But the expansion of human civilization off planet, also opens the possibilities for a full range of activities, such as orbital hospitals for those who would benefit from the lesser strain of microgravity; recreational facilities, to broaden participation in the scientific observation and study of the cosmos; and science, research, and manufacturing facilities to expand the resource base available to Earth's global economy.

Just as described elsewhere in this issue, the march of technologies along the road of increasing energy flux density, as a measure of man's economic progress, was foundational to Krafft Ehricke's plans. His conception of, and lobbying for, the development of an energy-dense liquid hydrogen rocket upper stage, allowed the creation of the Centaur, which opened exploration of the entire Solar System to the probing spacecraft of mankind.

In the 1960s, Krafft Ehricke explained that it would be the next step in propulsion, nuclear fission, which would open up cislunar space—meaning, literally, "on this side of the Moon"—beyond the robotic craft and short manned forays (such as Apollo), to the Moon. The purpose of lunar missions was to integrate this nearest body to Earth, which he described as our planet's "seventh continent," into our economy: Selenopolis was Krafft Ehricke's city on the Moon, engaged in resource development, mining and manufacturing, for use by the city, and export to Earth; the development of entirely new technologies defined by the unique environment of the Moon; astronomical observatories, for scientific studies that could not be done from or near the Earth, all to be powered by fission and then nuclear fusion. The city on the Moon would also be the testing grounds and way station to destinations further out.

But cislunar space, itself, Krafft Ehricke stated in 1955, is a critically important region for study. "Of scientific interest in a cislunar research program," he wrote, "are the distribution of cosmic matter in the Earth-Moon plane, and normal to it; the motion of discharged solar material in the Earth-Moon field, (which also involves a study of the magnetic field between Earth and Moon); cosmic radiation; and measurements of the Earth's albedo from greater distances." Krafft Ehricke saw the entire region from the surface of the Earth to the surface of the Moon populated with scientific instruments, as extensions of man's senses, in a constantly-upgraded series of scientific studies, and "for the realization of human space flights."

With the industrial development of the Moon, and families of space transportation vehicles allowing a thriving commerce of people and goods in cislunar space, mankind would be ready to tackle the next major challenge–Mars.

Space visionaries, including Krafft Ehricke and Wernher von Braun, were already planning mankind's exploration of the planet in the Solar System most like our own, before any rockets had even left the surface of the Earth.

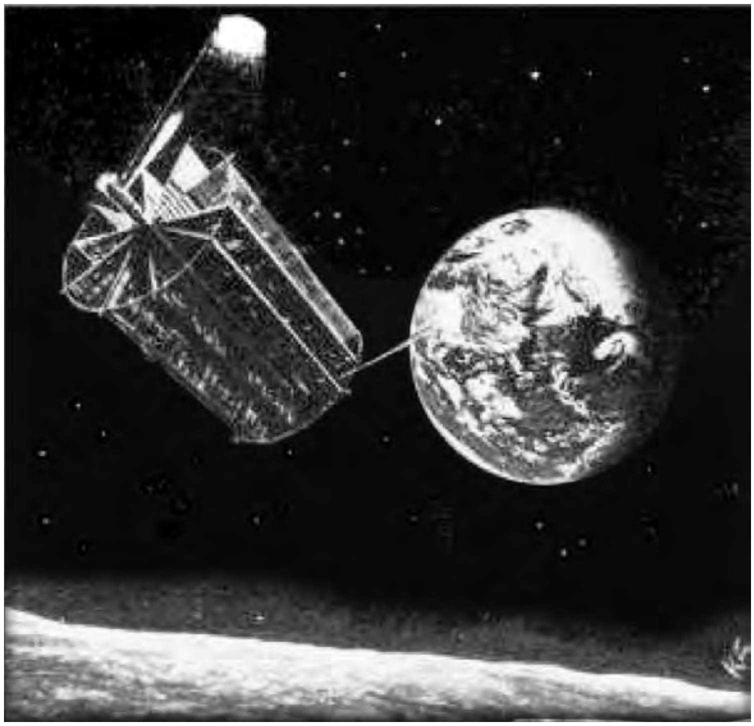
"Expedition Ares," written by Krafft Ehricke in 1948, but published for the first time in the Spring 2003 issue of *21st Century Science & Technology*, begins 400 years in the future, when Solar System space travel is commonplace. From that vantage point, he looks "back" to the year 2050, and first crew to head for Mars. In his work, the first mission is, in fact, a failure, and the crew must return to Earth. But exploration progresses, and the multi-decade development of the technologies to be brought in to play to explore the red planet, are described in fascinating detail.

But Mars was not the end point of Krafft Ehricke's vision. It extended out 30 billion years!

When The Sun Dies

In Krafft Ehricke's plan, the move of mankind into space would be enabled by a series of increasingly sophisticated, large, and complex infrastructural elements, to include living and working facilities, such as space stations, in near-Earth orbit and cislunar space. The stations would be steps toward creating the Androsphere–the integration of Earth and space. But these stations would not be merely bare-bones, temporary way-stations, but the build-up to the creation of new civilizations in the future.

The largest of his Earth-orbiting stations, Krafft Ehricke would name "Astropolis," a city looking to the stars, housing thousands of people. Much of its resources would come from the already ongoing industrial development of the Moon. It is described as the first step toward "extraterrestrialization;" an urban space facility in near-Earth space. Its purpose would be not only to provide economic integration with the Earth, but to begin to create a space-faring civilization, organized by the principle of the "moral imperative" that is unique to mankind.



Krafft Ehricke

Three dimensional civilization will be achieved when mankind can create his own planets, or "planetallas," in orbit around the Sun. In this early drawing, an androcell, is near the Moon. With their own propulsion systems, such new worlds will be able to leave our Solar System when the Sun can no longer enable the Earth to be an abode for life.

To prepare mankind for his ultimate exploration, Astropolis would include a Space University. Artificial gravity, from three-quarters to one full Earth gravity equivalent would be created by slowing spinning the city-sized station. This would accommodate living units, hydroponic farms, farm animals, industry, the University, medical, and leisure activities. Crews would undergo training, in preparation for more distant destinations.

But Krafft Ehricke was well aware that our Sun-centered neighborhood, and the Earth itself, will become a very dangerous place further in the future. Therefore, Astropolis, would spin off Androcells. These would be self-sufficient societies, no longer tied to the Earth, or even to the Moon. Androcells would be self-propelled, with a fusion power system, and free to travel throughout the Solar System. Krafft Ehricke further describes them as "man-made planetallas," with all of the facilities needed for an advanced society. He credited Konstantin Tsiolkovsky with a similar early concept, in which manmade planets were like a "string of pearls," in orbit around the Sun. Krafft Ehricke indicates his location of first-generation Androcells, at Mars, the asteroid belt, and Jupiter.

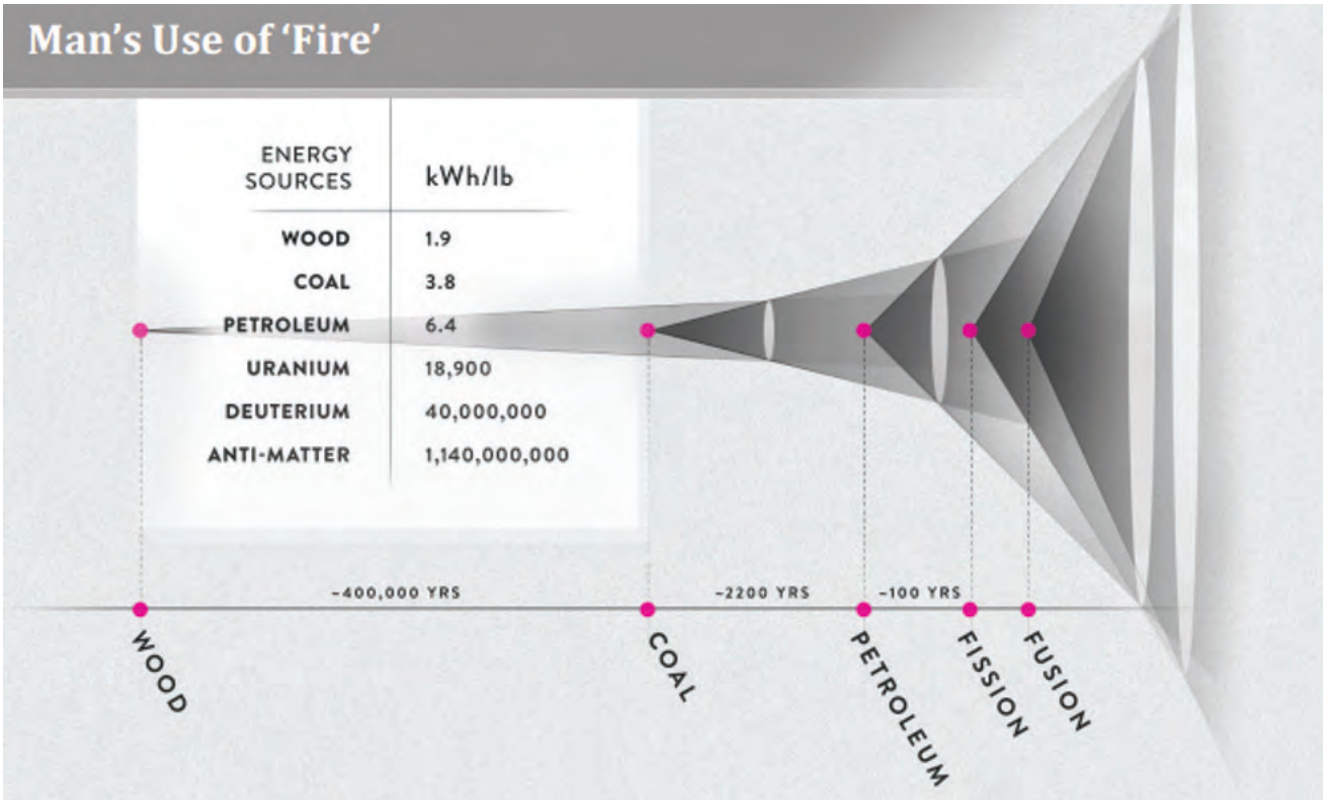
In a speech in Los Angeles in 1978, Krafft Ehricke described the future of Homo Extraterrestris–the population of the Androcell. The process of extraterrestrialization means that "the new place becomes the frame of reference, 'home;' the former place becomes foreign." The Androcells will form a network of "roaming, self-sufficient 'worlds;'"a process of an "outlook for the evolution of the universe in the next 30 billion years."

Using the plasma, which is ubiquitous in the universe, for fusion fuel, and the anti-matter which will similarly be available, mankind's new worlds will be able to start the journey to find more amicable environments for life, in preparation for when our Sun makes our Solar System uninhabitable.

More than one person who knew Krafft Ehricke, who died in 1984, has remarked that he lived in a sometimes lonely place–the future.

It is only that quality of thought and imagination that will equip mankind to meet the challenges we all face.

Krafft Ehricke's Extraterrestrial Imperative, by Marsha Freeman, can be purchased from Apogee Books, at or 1-888-557-7223, for $27.95. It is 302 pages, with an index and bibliography.



The Space-Time of Increased Energy Flux Density

by Creighton Jones

In contemplating the ability of mankind to increase his reach into the universe, we confront a curious irony respecting the essence of physical space-time itself. In general, we find that the power to further expand our reach into more distant nooks of the universe is a function of gaining an expanded mastery of increasingly "smaller" dimensions of physical space-time, a process which will come to be measured in terms of an increase in energy flux density (EFD). In other words, our ability to harness the increased power of physical reactions at increasingly smaller scales has correspondingly resulted in our gaining a power to go increasingly further out into our surrounding world, to the point that our closest binary star neighbor, Alpha Centauri, is now potentially within reach. This process has the character of adding, through creative discovery, a new dimension to the manifold of discovered principles of our universe. For example, the increase in power achieved as we shift our understanding of chemistry beyond the molecular level to the atomic level, (as with the shift from combustion of fossil fuels to controlled nuclear reactions) has opened up new potentials for physical control of processes, beyond what was possible in the domain of the lower energy density platform.

Coupled to this ironic relationship of the very large and the very small, is the challenge that this investigation poses to our assumptions about the nature of space itself: that space is a universal manifestation of extension itself, as deduced from a naïve, largely vision-based concept of space. The fallacy in this notion of spatial extension becomes clearer as we are forced to confront very real physical boundary conditions in space flight, especially when the prospect of human travel is involved, where very real challenges arise which might not be so obvious when such great "distances" are only considered in the abstract. That is, although in the domain of fantasy we can envision infinite linear extension into the increasingly small or the increasingly large, when this is at-

Figure 1
Exhaust Velocities for Different Rocket Fuels

Chemical	3,000 meters/sec
Fission	50,000 meters/sec
Fusion	100,000,000 meters/sec

EIR

One of the major factors that determines how fast the spacecraft can go is the speed at which the propellant comes out as exhaust. Chemical rockets, like today's Space Shuttle, burn liquid hydrogen and liquid oxygen, and the vapor that comes out as the exhaust is traveling at 3,000 meters per second. Nuclear fission provides much faster-moving exhaust particles—50,000 meters per second—but the promise of fusion is that it will provide orders of magnitude increases in exhaust velocity—to 100 million meters per second.

Figure 2
Specific impulse for different Rocket Fuels

Chemical	450 seconds
Fission	1,000 seconds
Fusion	100,000 seconds

EIR

Another way of comparing different propulsion fuels is by measuring their specific impulse. This figure, measured in units of seconds, describes the efficiency of the fuel used—it is the impulse per unit weight of the rocket propellant. Here, again, fusion promises orders of magnitude improvements over both chemical and nuclear fission fuels.

tempted in physical practice, we continually run into successive limits that can only be overcome through the introduction into practice of a newly discovered principle. This will become clearer as we proceed.

Onward to the Stars

A leading consideration when proposing a mission into the cosmos is the sheer weight of the spaceship with all its necessary instrumentation, because the heavier the payload, the more costly it is to launch, as measured in physical terms. The heavier the payload, the more thrust you will need to get it out of Earth's, or any other body's, gravitational well. Moreover, each fuel source employed defines certain upper limits in terms of mass, distance, and time relations achievable for a mission. Thrust, which is a measure of the force that accelerates the rocket, is a function of the fuel type you are burning: how much and at what rate. So generally, the larger the payload, the greater the amount of fuel required. It must be kept in mind that the fuel yet to be burned has to be calculated into the equation for weight. So, for example, longer trips will naturally require carrying more fuel, and that fuel has to be taken into the weight consideration of the ship, up to the point in the journey that the fuel is used for propulsion.

This already confronts us with the physical reality that the choice of use of any of the various fuel sources must be considered from the standpoint of the physical limits of its usefulness, as understood by such measures as the relative distance, and the time to traverse that distance, that the fuel can be employed for, as this is a function of what can be characterized as the Energy Flux Density (EFD) of the particular fuel source. EFD is a measure of the power brought to bear per unit of physical space-time; the more action or energy that you can concentrate in a given volume, the higher the energy flux density you achieve. This is a qualitative, as opposed to simply a quantitative phenomenon, and the question of the achievable density is the key. For example, although you could produce, through the combustion of around 20 billion molecules of methane (the primary component of natural gas), the 200 MeV of energy produced through the fission of a single atom of U-235, the diffuseness (volume) and quality (form) of the energy generated in natural gas burning renders it incapable of triggering a nuclear chain reaction. Compare that to the case with an initial fission event which releases some of its energy in the form of high-velocity neutrons, operating at an atomic scale, that then go on to trigger subsequent fission events. Not to mention the fact that through the chain reaction, new elements are produced through the transmutation process. Hydrocarbon combustion simply doesn't have the concentration of energy or power, or the *quality* of action, that is, the EFD, to effect processes at an atomic scale. So fuels with a higher EFD, as compared to those with a lower EFD, can produce the same relative amount of energy, but with less fuel and in a form which is of a qualitatively higher power.

A Brief Overview

This qualitative distinction between different fuel types, as measured in terms of EFD, pertains to modes of travel and dominion of human control. The first non-muscle driven form of transportation, was sailing. Wind power, as well as ocean currents, both of which are used to drive ships across seas and oceans, are a function of disproportionate solar-thermal heating of the atmosphere and hydrosphere and represent a relatively low EFD, that leaves mankind at the whim of relatively uncontrollable external factors. The next level in increased power to travel, comes in the form of liberating, through combustion, the stored energy of organic compounds in wood, and more importantly coal. Coal-driven locomotion afforded mankind the ability to have self-determined control of the continents. Man was able to advance further with the development of petroleum-based fuels, which utilized a greater depth of understanding and refinement of processes at the molecular level, where the higher energy-to-weight ratio allowed for their use in flight, adding yet another dimension to man's domain. The upper limit we have reached in the use of chemical reactions for propulsion is that used in rockets, such as the Saturn V rocket, used to put a man on the Moon.

The next level of development is that of controlling processes at an atomic level, that is, nuclear reactions. With an energy density orders of magnitude above that of chemical fuels, nuclear power provides an ideal power source for a reusable craft to fly heavy-load missions, allowing for manned control of the space between low Earth orbit and the Moon, as this was envisioned in NASA's development of the Nuclear Engine for Rocket Vehicle Application (NERVA) program. Nuclear rockets could also be utilized for long-duration unmanned cargo transport, to such further reaches as Mars.

Beyond nuclear fission, lies the promise of fusion-powered rocket ships, to be realized through gaining a greater understanding and control of processes at the atomic and sub-atomic level. With the power density achieved with fusion power, we will have the ability to generate an acceleration of 1 Earth gravity (1-g), that would allow for ideal travel time and lift capacity to put humans on Mars and open up the entire Solar System, out to the moons of Jupiter, to manned exploration, and in the process, achieve velocities which are within an order of magnitude of the speed of light. The next achievement, which would bring us up against the current limits of understanding the processes in the universe, would be the controlled use of matter-antimatter reactions, and will require us to penetrate even further into the sub-atomic domain.

Here the challenge would not lie in producing the reaction, as it is with fusion, but in fact creating the material to be used in the reaction, i.e. the anti-matter itself. For this, we will need to expand, fundamentally, our understanding of what matter is, which necessitates making breakthroughs in our conception of sub-atomic properties, such as spin and charge. The proposed designs for the rockets themselves call for taking advantage of such anomalous quantum properties as super-position and quantum coherence, which will allow for achieving even greater material densities, a fundamental parameter for long-distance spaceflight. One such design was presented at the 2004 NASA/JPL Workshop on Physics for Planetary Exploration, where a team proposed using anti-hydrogen fuel in a Bose-Einstein Condensate state, which would allow for an even denser packing of material per volume than is otherwise achievable under standard material conditions. With matter-antimatter reactions, we are utilizing, in a near-perfect way, the conversion of matter to energy described in the famous $E= mc^2$ equation of Einstein. With the density of power this affords, rockets will be able to approach velocities over half the speed of light, which puts the nearest star to our Sun within reach, at a travel time of about 9 years. Again, the increased EFD and the new power this affords man – in this case, the expansion of the domain under man's control – is a function of adding new principles to our manifold through creative discovery.

A Biological Consideration

Considerations of achievable energy flux densities for different fuel sources take on even greater significance when you add "manned missions" to your manifold of parameters. At that point, you must account for biological and psychological effects of space travel, where the duration of the flight is of critical importance. First to be considered are the yet little-understood effects on the human body of prolonged exposure to various forms of cosmic radiation which we will encounter outside the protection of Earth's atmosphere. On-board shielding, to the degree that it develops, will provide some protection, but the greatest mitigation of effect will come through reducing the time of exposure by shortening the travel time. At present, the ideal duration of travel for a trip from the Earth-Moon orbit to Mars, for example, is that achieved by a ship operating at one gravity acceleration, which should offset at least the loading effects of microgravity exposure, and would put us on Mars in 7-10 days. As mentioned above, the one, and perhaps the only physically viable means of achieving this is through the use of directed fusion powered rockets. Also, a 7-10 day trip will be much more psychologically tolerable than the trip of many months we can expect from chemical rocket propulsion.

Conclusion

In conclusion, we must see that the ontological nature of reality is not one that can be understood from a naïve sense-derived notion of space and time. Rather, our active knowledge of physical space-time is constantly changing in a non-linear, qualitative fashion, as a function of the creative discovery of universal principles. Furthermore, our notions of scale, into the very large and very small, are intrinsically bound by those underlying principles, and our accessibility to processes at different scales is not a function of simple extension "out" or "in" so to speak, but of revolutions in our knowledge of the underlying order of the physical universe. This is demonstratively seen in mankind's leaps from lower to higher order Energy Flux Density platforms, and the power to act these leaps afford us at qualitatively different scales.

Interview: Academician Anatoly Koroteyev

An Inside Look at Russia's Nuclear Power Propulsion System

Academician Anatoly S. Koroteyev is General Director of the Keldysh Research Center, one of Russia's leading centers for space engineering. A full member of the Russian Academy of Sciences since 1994, he has been officially honored by the Russian government for his work on space propulsion and power technologies, as well as being well known for developing plans for manned expeditions to Mars. He sits on the Russian Academy of Sciences Council on Space, is a member of the International Academy of Astronautics, and served as President of the Tsiolkovsky Russian Academy of Cosmonautics in 2005-2011.

Academician Koroteyev participated in the September 2012 International Specialized Symposium: "Space & Global Security of Humanity" in Yevpatoria, Ukraine (see page 28). He gave this interview to 21st Century Science and Technology *on December 3, 2012 in the form of written responses to questions from staff writer Benjamin Deniston. The interview has been translated from Russian.*

21st Century: The Keldysh Center is working on developing a spacecraft using a megawatt-class nuclear power propulsion system (NPPS), and a prototype is expected to be completed in 2018. What other agencies are involved in this project, and what is the role of your Center? What has the progress been in this work?

Koroteyev: Under a Russian Federation Presidential Directive dated June 22, 2010, the Keldysh Research Center is the lead organization for the project to develop a spacecraft that uses a nuclear power propulsion system (NPPS). The additional participants in the project represent a high level of cooperation among Russian organizations, chiefly Roscosmos and Rosatom [the state agencies for space exploration and nuclear power, respectively], with several of their subdivisions playing a special role: the Energiya Rocket and Space Corporation, the Chemical Machine-building Design Bureau, the N.A. Dollezhal Scientific Research and Design Institute, the Russian Scientific Center – Kurchatov Institute [Russia's premiere nuclear research lab], and others.

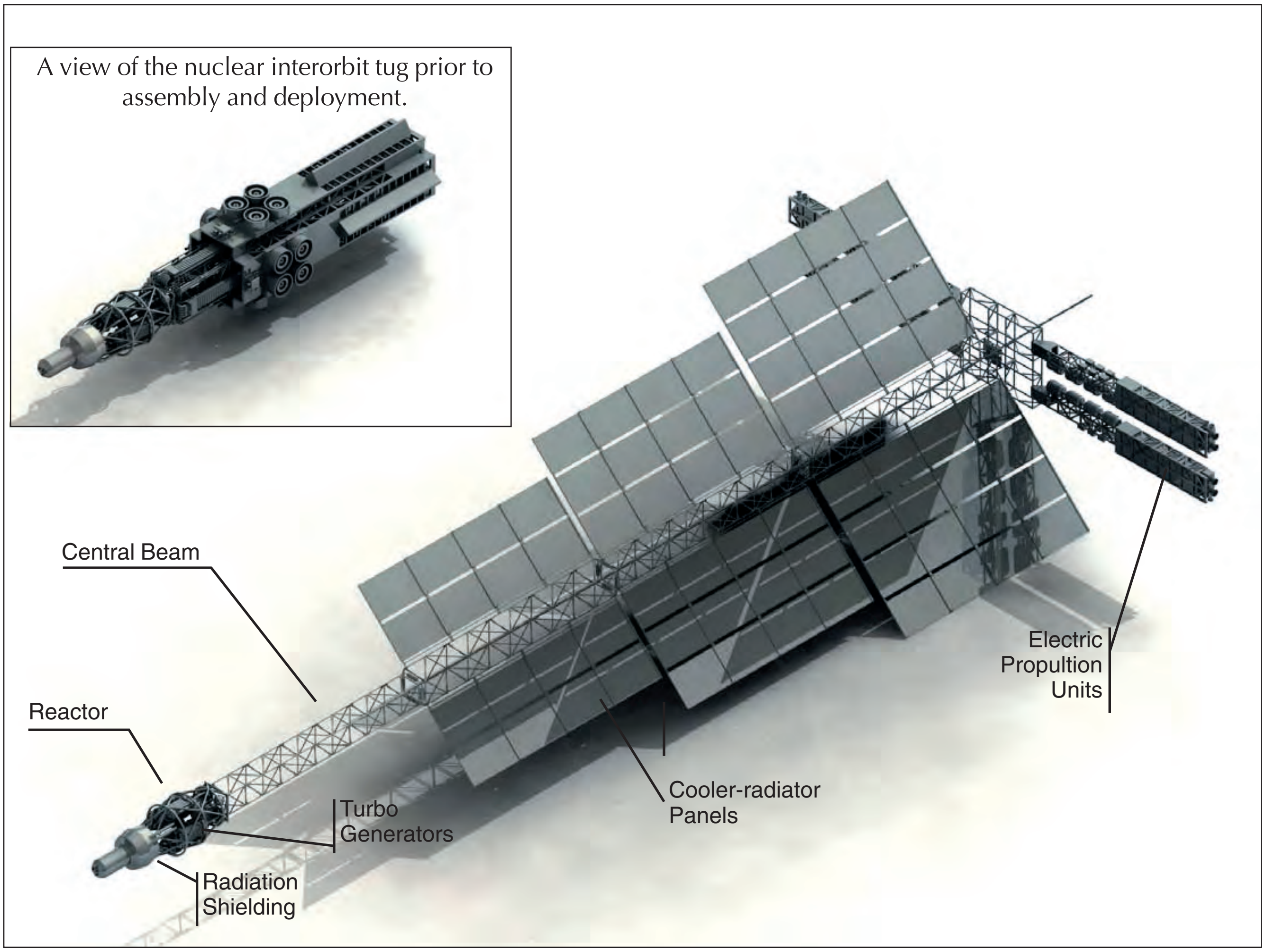
To date, a great deal of theoretical, experimental, and design work has been done, resulting in a draft design for a space transport using an NPPS. This work has enabled us to determine a prospective design for the spacecraft and its main features, and establish their feasibility.

Many people firmly believe that developing nuclear reactors for use in space is long overdue, and there are many potential applications, including improved communications, remote sensing, and propulsion systems. What do you think are the most exciting and beneficial applications for nuclear reactors in space?

I agree with the view that the introduction of nuclear power in space technologies is seriously behind schedule, and that is one of the reasons for the decline of the world-wide rate of growth in space exploration during the past 20 to 30 years. NPPS transport systems open up qualitatively new potentialities in space, in particular for improved information systems and the possibility of protecting the Earth from asteroids. They also open the way toward achieving compact power units for use in space, including on other planetary bodies, as well as for expeditions into deep space.

Because of the development of variable-trajectory spacecraft, it is becoming possible to do efficient space debris clean-up and to supply electricity to other spacecraft. In a number of emergency situations, it would be possible to redirect spacecraft onto their intended trajectories.

This will bring space communications and remote Earth sensing to a new level, which would not have been achievable using spacecraft based on solar or chemical energy sources.



Keldysh Research Center

A graphic design of the nuclear interorbit tug, powered by the Nuclear Power Propulsion System (NPPS).

At the 2012 International Specialized Symposium: "Space & Global Security of Humanity" in Yevpatoria, Ukraine, you spoke of using the NPPS for defending the Earth from asteroid impacts. What advantages will the megawatt-class NPPS provide over existing solar-electric or chemical propulsion systems for defending the Earth?

The NPPS opens up the possibility of using so-called gravitational tractors to divert the trajectory of an asteroid to a fly-by at a safe distance from Earth.

Over the past few years we have heard statements from President Vladimir Putin, Roscosmos Chief Vladimir Popovkin, Deputy Premier Dmitry Rogozin, and others about Russia's plans to develop permanent infrastructure on the Moon and in space, including possibly returning man to the Moon. How will the development of the NPPS contribute to these goals?

By using nuclear power, we can create infrastructure with sufficient energy supplies for successful planetary expeditions, something that could not be achieved by relying on solar energy alone.

In the United States, our difficulties in developing nuclear power in space have been chiefly political. We had a nuclear thermal rocket program which was shut down in 1972, despite showing immense promise. According to the recent studies I have seen, nuclear thermal rockets can provide significantly more thrust than nuclear electric systems, thus providing quicker travel times. Are there any programs at the Keldysh Center or elsewhere in Russia to develop nuclear thermal systems as well?

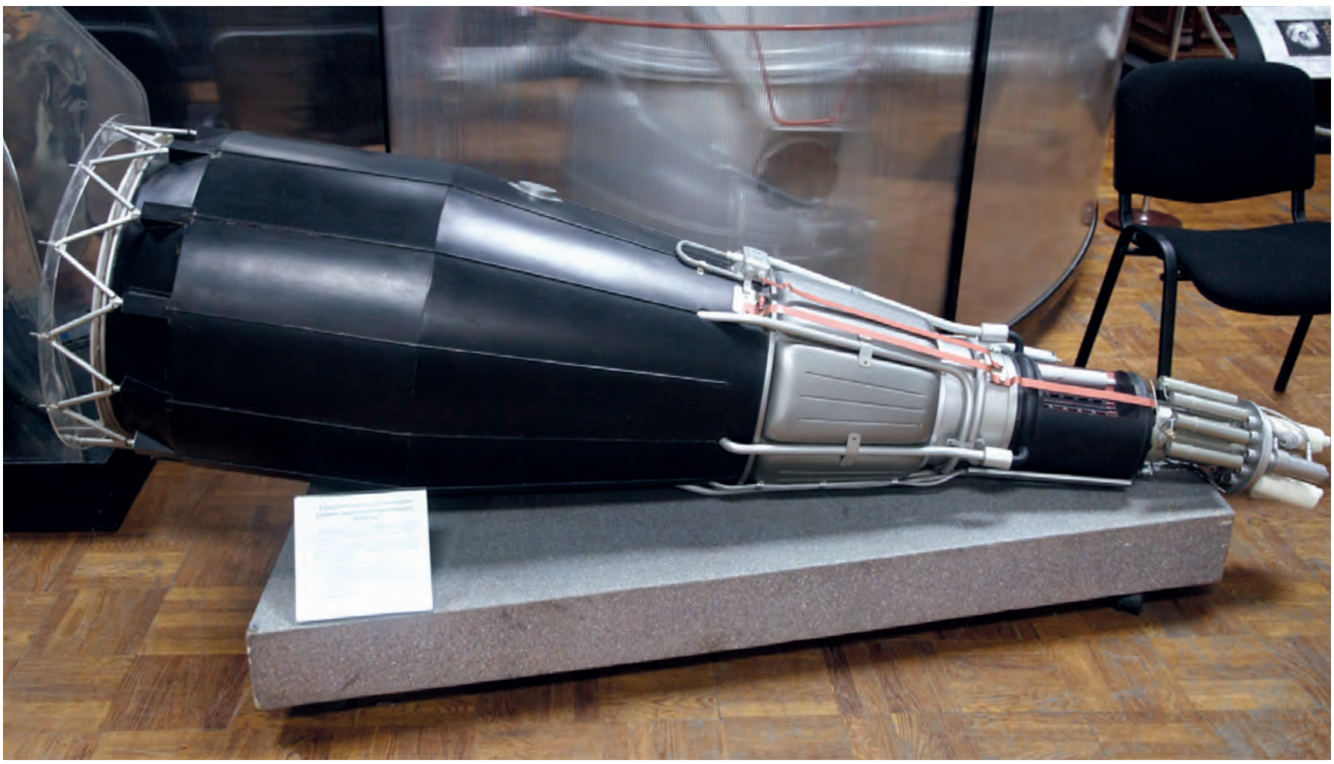
Plans do exist for the use of nuclear systems in which thermal energy is directly transformed into propulsion. Indeed, this would make it possible to achieve greater thrust values than is possible with electric engines. But it requires solving a number of complex challenges, related to ensuring the reliability of such engines. Higher temperatures are involved in the reactor, especially when heating a propellant that is chemically highly reactive, such as hydrogen.

For the challenge of manned deep-space flight, such as manned missions to Mars, prolonged exposure to radiation and the effects of prolonged zero-gravity can be detrimental to human health. For serious, large-scale Mars exploration, the energy densities of fission appear to be lower than needed. Only the energy densities of thermonuclear fusion could provide enough constant acceleration/deceleration to simulate Earth gravity, possibly alleviating the biological effects of microgravity. This would also reduce the travel time to Mars to weeks, or even days, meaning less exposure time to harmful radiation. Are you aware of any programs, either at the Keldysh Center or elsewhere, to make this next great leap into the domain of thermonuclear fusion systems for space travel?

I think that it is premature to talk seriously about using thermonuclear energy in space: even on Earth, an effective way to utilize thermonuclear energy has not yet been put forward, although work in this area has been going on for over half a century.

Despite the fact that, to my knowledge, Russia is the only nation actively developing the exciting new technology of nuclear propulsion, I have seen little coverage of this in the western media. Are there any other ongoing programs at the frontiers of space research and exploration, either at the Keldysh Center, or in Russia generally, which you would like to bring to the attention of our readers?

Our view is that the issue of using nuclear power in space should become more international in the commercial respect, and I think that the development of such cooperation would be welcomed in both the West and the "East." Perhaps a first step toward better acquainting Western specialists with Russia's work on this problem would be to publish in the USA some kind of an overview of Russian publications in the area of nuclear power in space, which would provide a clearer understanding of the status of this question in our country.



Polytechnical Museum of Moscow

This scale model of a Russian TOPAZ space nuclear reactor is in the Polytechnical Museum of Moscow. Russian scientists ground-tested the first TOPAZ reactor in 1971, which operated for 1,300 hours. It used 26 pounds of nuclear fuel, delivered 5 kilowatts of power, using thermionic direct conversion, and weighed 710 pounds. The first TOPAZ reactor was flown successfully in 1987 on two experimental Plazma satellites. The program was abandoned by Mikhail Gorbachev in 1988.

Interview: Dr. Stanley Borowski

With Committed Funding, We Could Develop a Nuclear Thermal Rocket for The Moon, Mars, Asteroids, and Beyond

21st Century

Dr. Stanley Borowski

Dr. Stanley Borowski has been a leader in nuclear rocket research and development work at NASA for 23 years. He is currently branch chief of the Propulsion and Controls Systems Analysis group at NASA's Glenn Research Center, and leads the nuclear thermal propulsion program. Dr. Borowski and his team have designed missions using nuclear thermal propulsion for exploration missions to the Moon, Mars, near-Earth asteroids, and the outer planets. Before joining NASA, Dr. Borowski worked at the Aerojet Propulsion Research Institute and the Oak Ridge National Laboratory. He earned his Ph.D. in nuclear engineering from the University of Michigan in 1983.

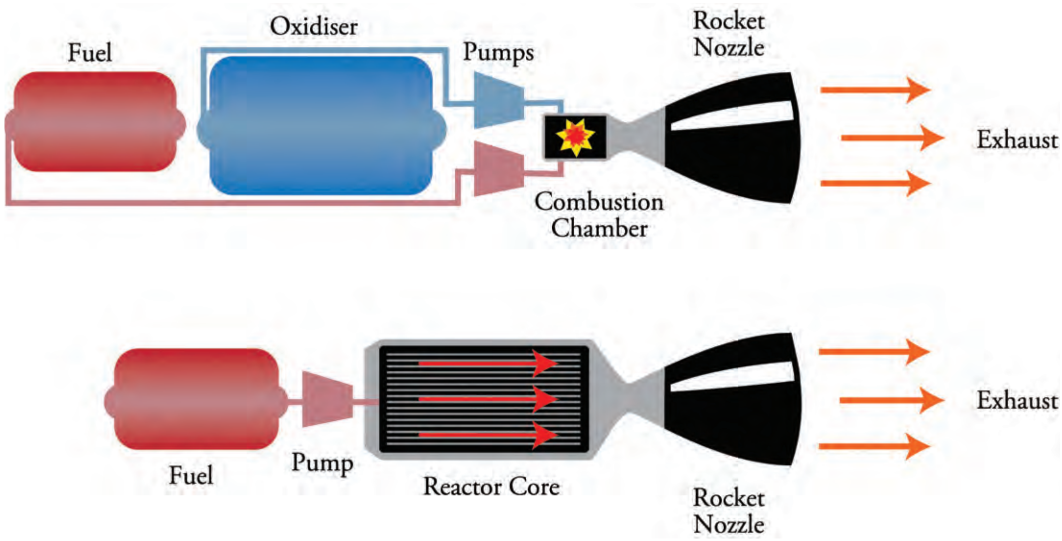
Dr. Borowski was interviewed by Peter Martinson and Marsha Freeman following his presentation at the Global Space Exploration Conference in Washington, DC, in May, 2012.

Peter Martinson: Dr. Borowski, you just gave a fantastic presentation on what's called "Nuclear Thermal Propulsion." So first, could you tell us what you do?

Borowski: Thanks, Peter. I'm the branch chief for the propulsion and control systems analysis branch at the Glenn Research Center (GRC), but I also lead the nuclear thermal rocket work that we're doing there, in support of the Nuclear Cryogenic Propulsion Stage (NCPS) project that's funded by NASA Headquarters and is being performed at three NASA centers: Marshall Space Flight center, Glenn Research Center, and Johnson Space Center.

Martinson: Could you explain what nuclear thermal propulsion (NTP) is?

Sure. A nuclear thermal rocket is a high power density, very high efficiency, high thrust propulsion system, that only requires one propellant. In contrast to chemical rockets which use liquid oxygen (LOx) and hydrogen, and use chemical combustion to generate energy, in a nuclear rocket, it's the fission of uranium-235 fuel within the reactor core which generates all the thermal power. So, what we're able to do is, in a very small, compact volume, generate a lot of power. We remove that power by using liquid hydrogen, which is flowed through the reactor core, picks up the heat, and then we expand it out a regular nozzle, like in a conventional chemical rocket, for thrust generation. The beauty of it is that, by using liquid hydrogen (LH2), the exhaust gas has a specific impulse (Isp), which can be defined as the pounds of thrust produced per pound of propellant per second flowing through the engine, in units of seconds, that is twice that of today's best chemical rocket—900 s for the NTR vs. 450 s for a LOx/LH2 chemical rocket. The other benefit of NTP is that it uses a lot of the same kinds of technologies that are used on a chemical rocket. It has pumps, nozzles, and LH2 propellant tanks. But with a NTR you get a 100% increase in Isp, compared to chemical, so as we look forward to using it in space, for exploring the Moon or going to a near-Earth asteroid or on to Mars, the key thing is to reduce the amount of mass needed to do those missions, and with nuclear thermal rocket propulsion you can do that.



Courtsey of Dr. Borowski

Comparison between chemical and nuclear thermal rocket operation. In a chemical rocket (top), the fuel is combined with an oxidizer, ignited, and the explosive reaction directed out the rocket nozzle. In a nuclear thermal rocket, liquid hydrogen is flowed through the reactor core and heated to extreme temperatures, which forces it to evaporate and expand, and it is then directed out the rocket nozzle.

Martinson: So, you'd say that this is a much better fuel for propulsion than just regular chemical fuels for exploring the Solar System?

Yes, that's right. Chemical propulsion has limitations, but we will always need it, because chemical rockets have a much higher engine thrust-to-weight ratio. Although they have twice the specific impulse, nuclear engines are heavier. So, from that standpoint, they're really positioned to be propulsion systems to take us from point A to point B in space, whereas a chemical rocket is what we're going to use to lift off from the deep gravity well of Earth and deliver all of our spacecraft components to low Earth orbit for assembly. So no matter what kind of spacecraft we develop, we'll need chemical rockets to get us into orbit. Then, we'll be using chemical rockets, in all likelihood, to land on the surfaces of those planetary destinations, whether it be the Moon or Mars. The nuclear engines are primarily the propulsion systems for point-to-point transfer through space, and not for launching off the ground, or for landing on a planetary body.

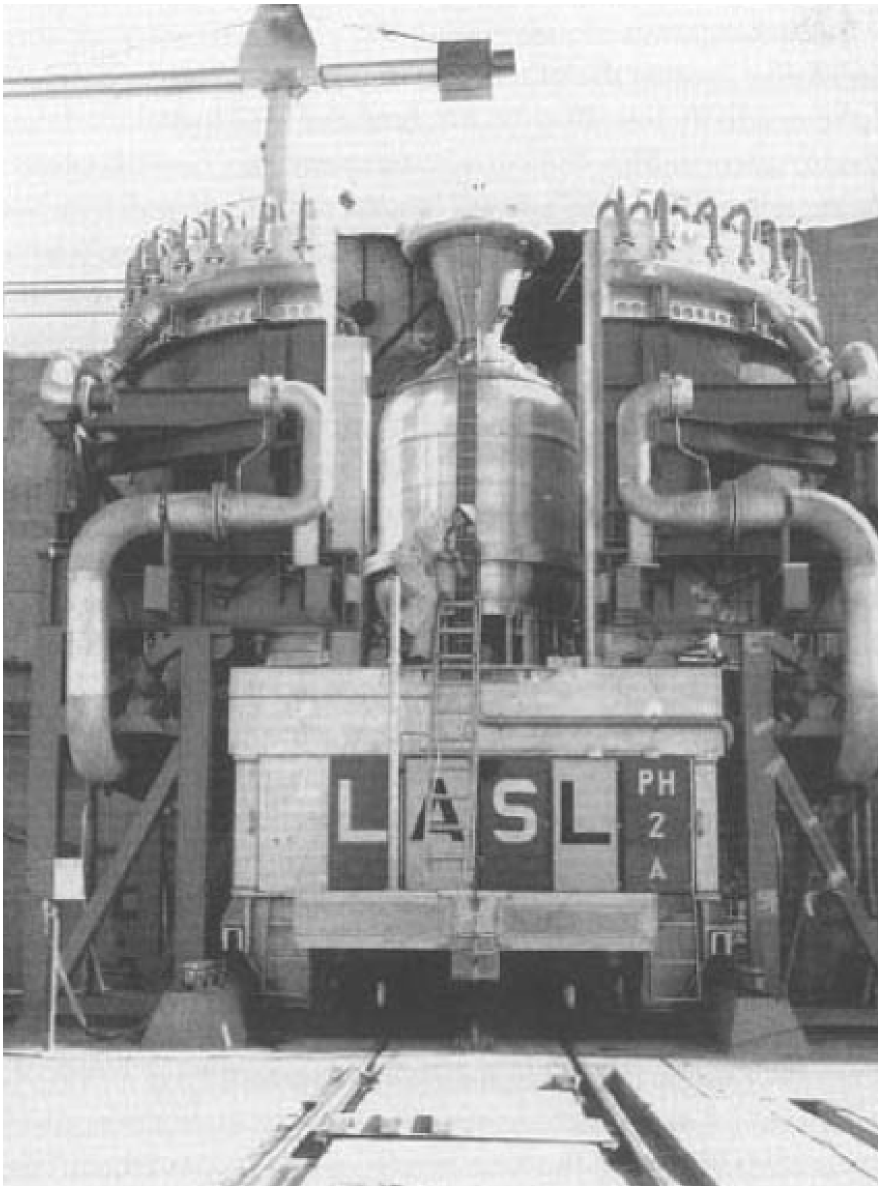
Martinson: Now the United States has some history in working on and developing this kind of a rocket. Could you review some of that?

Sure. Nuclear rocket development efforts started in the late 1950s, and during the 1960s, NASA and the then-Atomic Energy Commission (AEC) conducted what was called the ROVER and the NERVA nuclear rocket programs. NERVA stood for "Nuclear Engine for Rocket Vehicle Application." During that period, NASA and the AEC designed, built, and tested 20 nuclear rocket reactors, out at the Nevada Test Site, in sizes that ranged from 25,000 lbf[1] to 50,000 lbf, then 75,000 lbf, all the way up to a 250,000 lbf engine, which produced 5,000 MW of power when it was producing thrust. So, that was the biggest reactor that's ever been tested on the ground.

Martinson: Can you compare that to a conventional power reactor?

Yes, I can. A conventional, large commercial power reactor typically produces approximately 1,100 MW of electrical power at about 33% efficiency, so you're talking about 3,300 MW of thermal power being produced in a large terrestrial power reactor, versus 5,000 MW generated in the 250,000 lbf Phoebus-2A nuclear rocket tested in the ROVER program. Now, there is a difference in these systems. Nuclear engines have a lot of enriched uranium in them, because their focus is to generate a lot of power in a short period of time, to generate high thrust. The temperatures that these fuels operate at are a lot higher than that in terrestrial reactors. So, there is the potential, as we develop this technology and move forward, that higher temperature fuels for terrestrial gas-cooled reactors could become possible. In fact, gas-cooled reactor technology that uses small particles of fuel with multiple

1. Lbf means "pounds-force," as opposed to lbm, which is "pounds-mass."



NASA

The Phoebus-2A, one of twenty nuclear thermal rockets tested under the ROVER and NERVA programs.

coatings on them—called "biso" and "triso" pellets – could benefit in the future from using higher temperature coatings that are being investigated for use in NTR engines.

Martinson: You mean the pebble bed reactors?

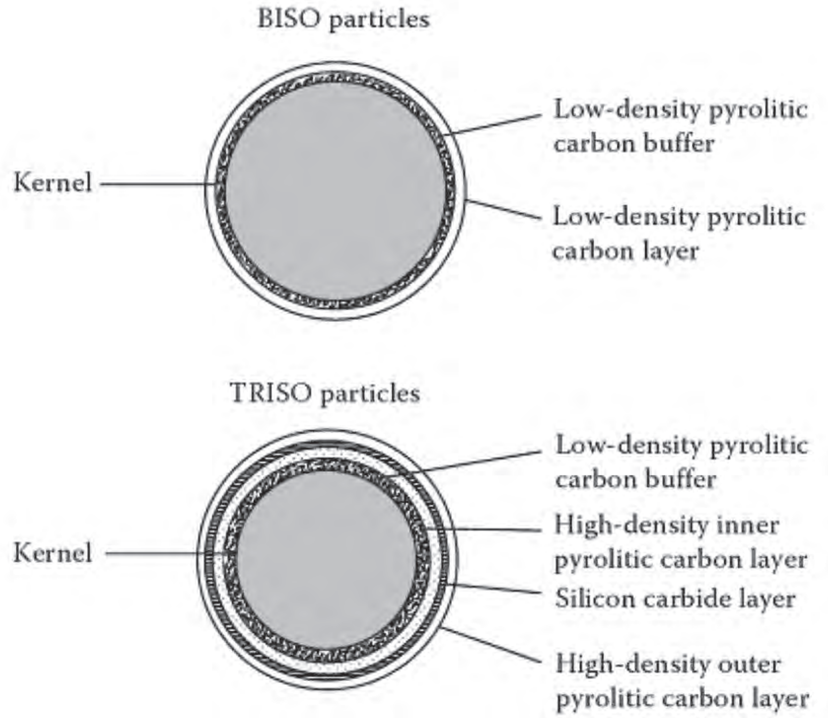
Yes, pebble bed-type reactors that contain the nuclear fuel in graphite blocks. So, with this kind of technology, we could potentially go to higher temperature coatings, that have zirconium carbide on them rather than silicon carbide. In the future, once we've revalidated our technology, if it looks applicable, it could find ways into the terrestrial gas-cooled reactor area, and allow higher temperature, higher efficiency reactors, that are based on gas-core type systems, not the pressurized water reactors.

Martinson: Now we don't have a nuclear rocket yet. Could you say how this program ended?

Great question. During the '60s, we had the Apollo program. We were going to land a man on the Moon and return him safely to Earth before the decade was out. After that we had plans to build a base on the Moon, and then to go on to Mars. In fact, Wernher von Braun, who at that time was developing the Saturn V rocket, and was also the director of the Marshall Space Flight Center, had a three decade long vision called the "Integrated Space Plan (1970-1990)," which called for building a shuttle, having an orbital space station, then after our initial landing missions, building a base on the Moon, and then going on to landing humans on Mars in the early 1980s. Central to developing a lunar base and transporting cargo from Earth to the base, then going on to Mars, was an advanced propulsion system, and what von Braun was talking about was the NERVA nuclear rocket. So, back then, we were thinking a lot about NTR technology.

But, in the end, both the Apollo program and the ROVER/NERVA NTR programs were canceled due to a combination of political issues. The use of large systems that were costly and were being thrown away, like the Saturn V, and not being reused probably came into play, or maybe it was the fact that the United States had won the race to land humans on the Moon. Maybe we were victims of our own success, because, after a while, the public got bored seeing astronauts walking on the Moon. There were actually reports of people calling up the local networks and saying, "What are you doing? 'I Love Lucy' is on right now, and you're showing some astronaut jumping around like a bunny on the Moon." So, it was a combination of things.

So they canceled Apollo missions 18, 19, and 20. The Saturn V's for those missions are on display at the Kennedy Space Center, the Marshall Space Flight Center, and the Johnson Space Center. With the conclusion of the Apollo 17 mission in December 1972, the Apollo program came to an end. The United States decided it wasn't going to go on to Mars, and the nuclear rocket, which was primarily being developed to send humans to Mars, was terminated shortly thereafter. In January 1973, a month after the final Apollo 17 mission, they canceled the ROVER/NERVA program.



IAEA

Bi-isotropic ("biso") and tri-isotropic ("triso") nuclear fuel pellets. Both pellets contain a kernel of uranium fuel, coated by several layers of material.

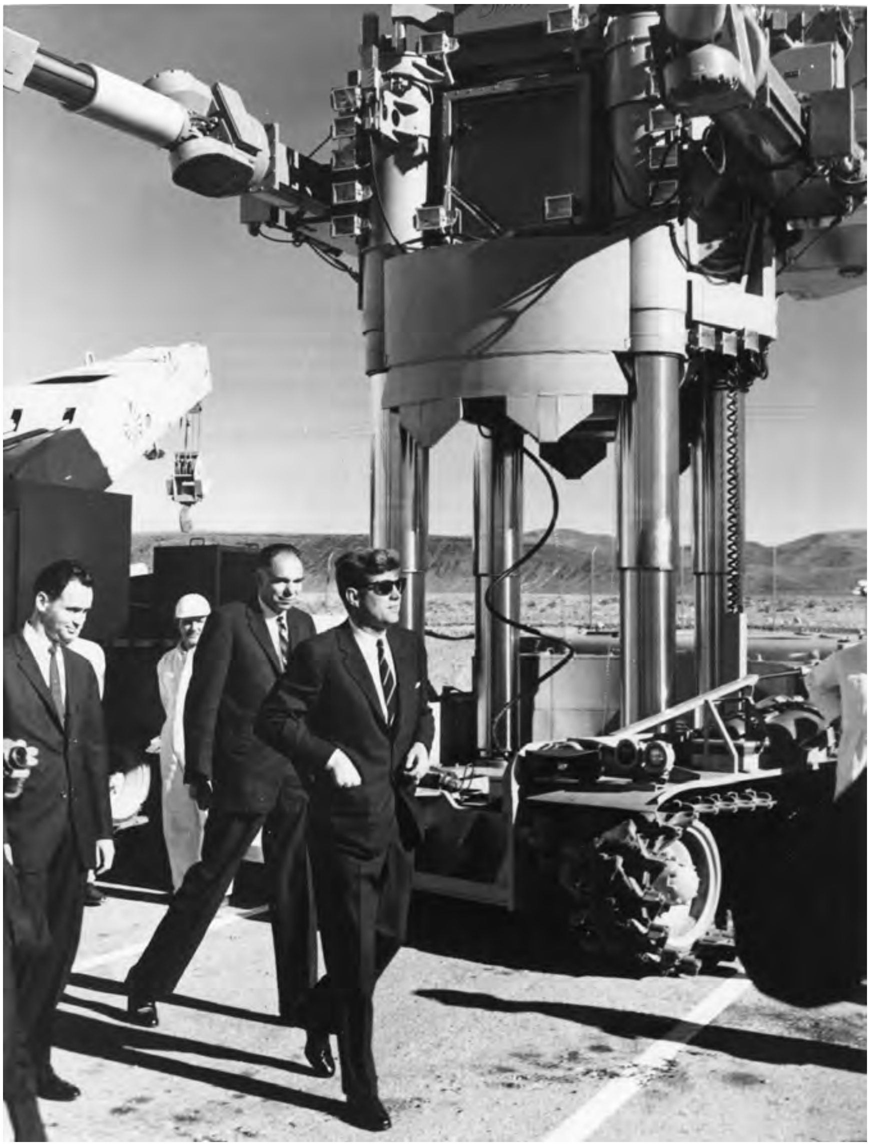
Martinson: Even though the NERVA program was at a very high level of completion?

It was at a very high level. NASA has readiness levels, and NERVA was at the 5 and 6 level, and it's at that point that you're going to a flight engine. So, it came very close, but if you weren't going to go back to the Moon, and weren't going on to Mars, then why do you need it? So, NASA decided to use its resources to build a space shuttle, a reusable space truck, that could continue to get humans into orbit, so at least we had a way to continue to send people up and down, potentially deploy and retrieve satellites, and from there the logic sequence was, once you have a space truck going back and forth to low Earth orbit, eventually that space truck would have to go somewhere. So you'd have to go on to build a space station, which we ultimately did do, and we did use the shuttle and its cargo bay as the primary vehicle for delivering up the components. But, because you were limiting all the components of the space station to smaller 20 ton increments that could fit in the shuttle cargo bay, it took a lot longer to build it, and to get it deployed. If you had a Saturn V, you could have had a couple of the Skylabs launched in relatively short order, say within a few missions, and had a giant space complex operating in Low-Earth Orbit (LEO).

Martinson: Now, part of the context of your talk is that, now, 35-40 years later, there's renewed interest in the rocket.

That's exactly right. NASA conducted its Design Reference Architecture (DRA) 5.0 study in 2007 and 2008, and the report, NASA-SP-2009-566, came out in July, 2009. This effort was followed by the Augustine panel which went back and reviewed NASA's proposed exploration plans, and then provided their recommendations about whether they thought NASA was on the right track. Under the Constellation program, NASA had plans to build a heavy lift launch vehicle, the Ares V, the crewed Orion capsule and the service module, a large lunar lander, called Altair, and we were going to return humans to the Moon. But, I think, with the change in administration, there were a number of people who were asking, "is this the right step? Are we doing the right thing?" So, the Obama Administration commisioned the Augustine report to evaluate various plans and options.

I think it was the consensus that, while we certainly needed a heavy lift launch vehicle to move forward, in times of a limited budget, it might be more advantageous to focus on one of the pieces of the transportation puzzle, namely, the in-space transportation system, as an initial starting point. By developing the technology for that piece first you can then go to multiple destinations within the Solar System, whether it be lunar orbit, or a near Earth asteroid, or to orbit Mars and its Moons. NASA's current space policy that was issued in June 2010 under the Obama administration calls for NASA, as its primary fo-



NASA

President John F. Kennedy, visiting the Nuclear Rocket Development Station at Jackass Flats, Nevada, in December 1962. Behind him is the "Beetle," a self-propelled robotic manipulating machine. At the extreme left is Dr. Harold Finger, head of the nuclear rocket program.

cus, to develop the capabilities that can allow humans to visit a near Earth asteroid (NEA) after 2025 and the current date that we're talking about for such a mission is probably around 2028, followed by an orbital mission of Mars before 2035.

You may have heard at the conference about 2033 as the Mars mission date because for short orbital stay missions, there's significant variation in the energy requirements to get from the Earth to Mars and back again. The orbital mechanics of Earth and Mars go through a minimum, and then a maximum and this "min-max cycle" occurs every fifteen years. It just so happens that 2033 is one of those minimums. So, if you want to do a short round-trip orbital mission to just demonstrate that you can get people to Mars and bring them back healthy and sound, 2033 would be an opportune time to do that.

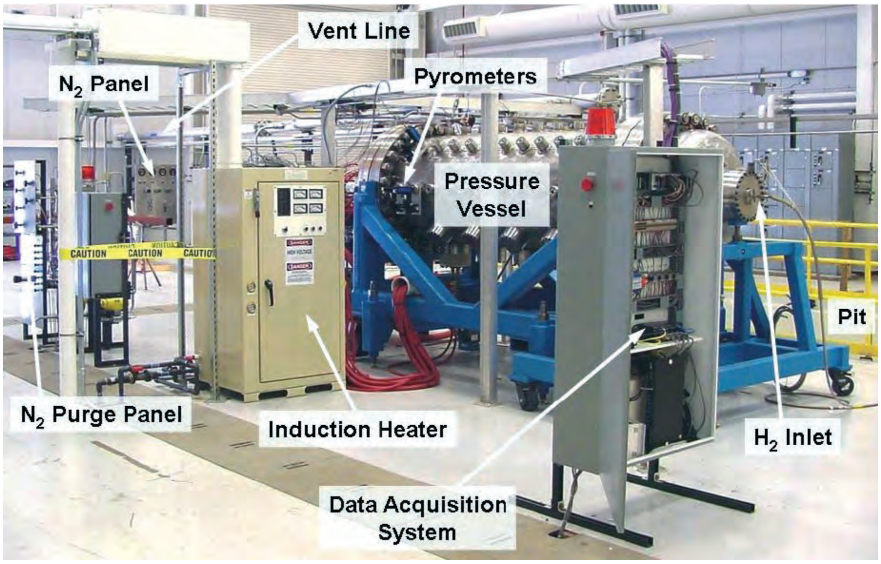
Afterwards, you can transition to a landing mission, which would give you more time to develop a Mars lander and other key surface systems.

Focusing on transportation initially is probably a good idea because it is one of the critical pieces you need no matter where you're going. Whether it's to the Moon, Mars or its moons, or to an asteroid, in-space transportation is one of the key things, and how efficiently and affordably it gets you there is one of the key questions.

Martinson: Could you describe the current roadmap for the development of the Nuclear Thermal Rocket?

I'd be glad to. NASA is currently evaluating different concepts and approaches to help it lay out its plans for what's required to get humans out of low Earth orbit and that could involve returning humans to the Moon or sending them to a NEA before embarking on a human mission to Mars. In 2010, NASA began putting together plans for how it would conduct an affordable nuclear thermal rocket program. We initiated this program in fiscal year 2011 under AISP—the Advanced In-Space Propulsion program—which was a part of ETDD the Exploration Technology Development and Demonstration program. Under the nuclear thermal rocket component of AISP we identified five key elements. Fuel recapture, revalidation and development is one of these key elements.

We identified two candidate fuels. The first fuel option is NERVA "composite" fuel, consisting of a graphite matrix material fuel element containing uranium-zirconium carbide fuel. The second fuel option was the backup to the ROVER/NERVA carbide-based fuel and is a ceramic metal fuel referred to as "CERMET." In NASA's current NTP technology development effort, we're pursuing both options. Working with the Department of Energy,



NASA

The Nuclear Thermal Rocket Element Environmental Simulator (NTREES), at NASA's Marshall Space Flight Center, is designed to closely approximate the conditions within a nuclear reactor, in order to test fuel element design for the NTR.

we want to fabricate both fuel types, and then do non-nuclear testing of them in the test facility at the Marshall Space Flight Center called NTREES, which stands for Nuclear Thermal Rocket Element Environmental Simulator. In this test chamber we'll be able to subject the fuel element to the kind of pressure and hot hydrogen environment it would see in an operating engine, but we will use high-power radiofrequency or RF power as the substitute for nuclear power generation to heat and simulate the actual temperature profile along the length of an element.

Martinson: So it's not actually a nuclear reactor?

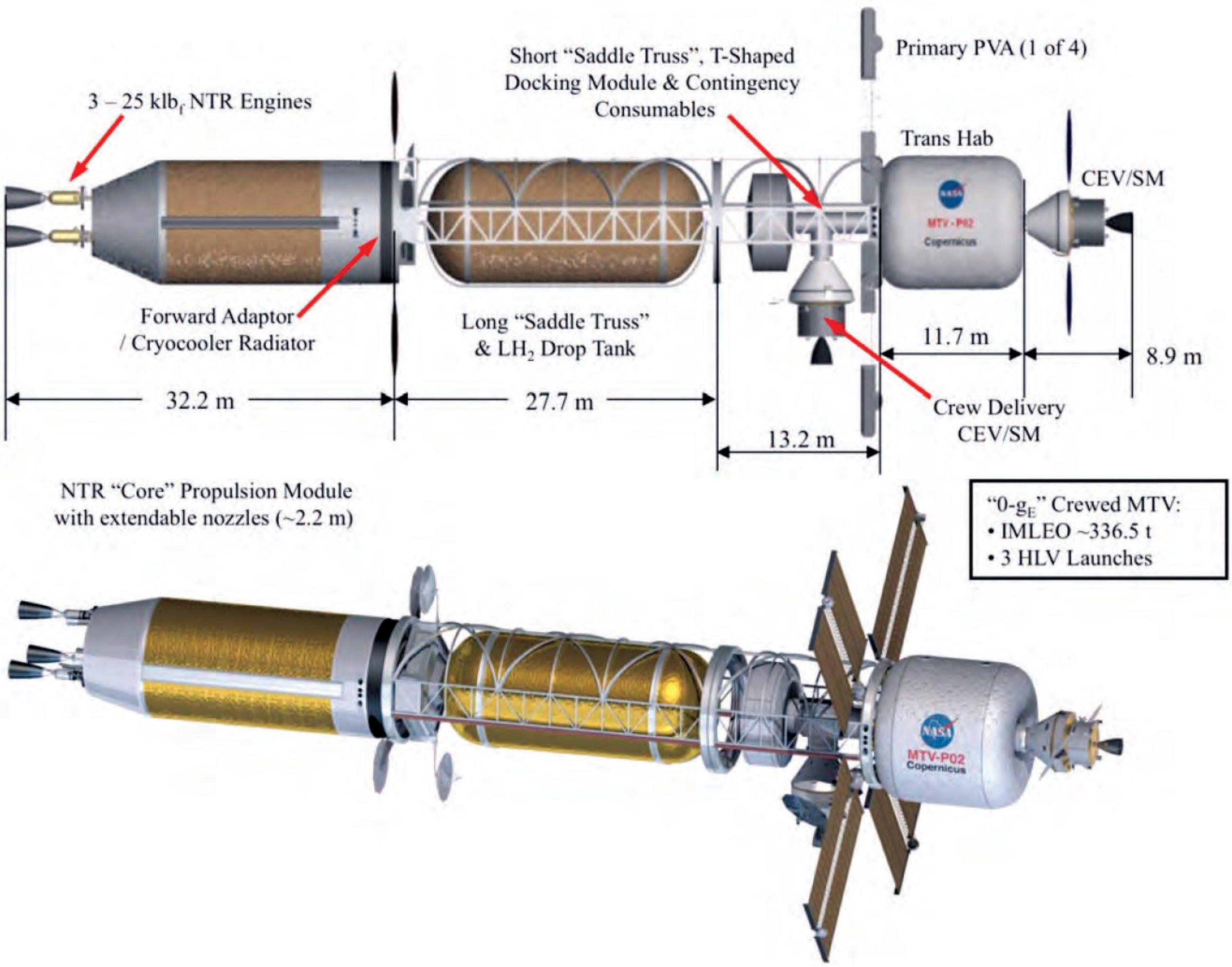
That's right, NTREES is not an actual nuclear reactor, but it simulates many of the operational conditions. It would expose the fuel, the materials, and the coatings to the kind of temperatures that a fuel would see, and hopefully, if it all hangs together successfully then it becomes a strong candidate for follow-on irradiation testing in the Advanced Test Reactor (ATR), located at the Idaho National Laboratory. So by using separate effects testing involving non-nuclear testing of full length fuel elements in NTREES, and then irradiation testing in ATR, we should be able to validate the promising fuel element designs.

A second key element of NASA's NTR effort is evaluating affordable ground testing options. We can no longer test our engine in the open air as we did in the ROVER/NERVA program. Even though these tests would potentially be conducted at the remote Nevada Test Site (NTS), we can't just let the hydrogen exhaust escape into the atmosphere. So, when we do these tests, the exhaust has to go into either a contained exhaust scrubber system, located above ground, which could be expensive, or we can exhaust into the ground out at the NTS into existing vertical shafts referred to as borehole tunnels, and use the soil as our large holdup tank and as our filter. The tunnel and adjacent soil surrounding it collects and filters the exhaust, and can hold it for a long period of time. We've already analyzed this concept which is called Subsurface Active Filtration of Exhaust or SAFE for short, and it looks to be a very effective test option, and could be very cost-effective as well.

Another key activity we're doing is detailed state-of-the-art engine modeling. As I said earlier, twenty rocket reactors were tested during the ROVER/NERVA program. On a lot of these rocket/reactor tests, they designed and manufactured one engine, then rolled it out to the test site to start conducting tests, and when those tests were done, they rolled it back to the EMAD (Engine Maintenance Assembly Disassembly) facility at the NTS to examine the fuel elements while they were rolling out another one to test. They hadn't even gotten the feedback from the previous engine to make any required changes. So in that sense, it was kind of a gold-plated program similar to what existed during the Apollo days. We had to get a lot done in a short period of time, and limitations on funding wasn't an issue then. Today we can't conduct that kind of program, so we're focusing on two fuel types and two fuel element geometries. We'd like to use a common element design for each fuel option, validate it, then do detailed engine modeling, so we know all the energy deposition in every single element throughout the reactor core. That information will help us to program the RF power that we put in when we're testing these elements in NTREES, so that they're exposed to prototypical kinds of thermal temperatures that they would see in an operating engine.

So, detailed engine modeling, fuel element fabrication and testing, and validation of the borehole for an affordable approach are three of our key elements. A fourth important element is mission analysis and vehicle conceptual design. We're looking at a lot of different types of missions. Lunar missions, precursors robotic missions, human missions to near-Earth asteroids as well as to Mars. The reason why we do this is to determine what the requirements are on the engines. How long do they have to operate, how many restarts are there, what's the maximum temperatures that these engines will see? These are important questions and impact the test program for fuel development and validation. Requirements definition is an important activity also so it's a combination of all of these task elements. The fifth and final key task element is putting everything together into an integrated plan that makes sense and is affordable.

As I mentioned previously, all of this work started under the Advanced In-Space Propulsion program in fiscal year 2011, and is now continuing under the new Advanced Exploration System (AES) Project called the NCPS, the Nuclear Cryogenic Propulsion Stage. The five tasks discussed above are also key elements of the NCPS project, and we'll be working for the next three years to fabricate elements, test them, and at the end of these three years, be able to select one as our primary fuel and element design approach. Then we hope that in the next four years, say around 2015, to get the OK to go forward with an integrated ground technology demonstration test of a small engine by 2020. Using our common fuel element, we'd fabricate and bundle together a number of these elements in a smaller, lower thrust core, build it and test it out at the NTS using the borehole approach. And then, once we've validated that it operates successfully, take that same small engine design and do a flight-technology demonstration mission. Maybe we'd fly to a near Earth asteroid as a robotic precursor. Then five years after that, we'd scale up the core to the full-size 25,000



NASA

Concept crewed spacecraft for NASA's Design Reference Architecture (DRA) 5.0, featuring the NTR for in-space propulsion between the Earth and Mars.

lbf thrust engine, put together the vehicles that you saw in my presentation, then fly to a near Earth asteroid with a crew potentially by 2028, which is when a number of candidate NEA missions are available. That will set the stage for testing everything out in a deep-space environment so we'll be ready for a Mars orbital mission in 2033 or thereabouts.

Martinson: If you had the funding profile that we had back in the late 1960s and 1970s, a miracle happened, we got full funding for the Mars program, and we needed that nuclear thermal rocket, how would that change the program?

With "Authority to Proceed" and committed funding, we certainly could develop a NTR and the spacecraft needed for the missions and dates I discussed above. Since we are focused on a given size engine—25,000 lbf—rather than a single real big engine, we'd use a three-engine cluster of 25,000 lbf engines, because it provides an engine-out capability. If you lose an engine, you still have two good engines to continue on. If you have only one big engine, and you lose that, then you're stranded and could lose the mission and the crew. So, engine-out is a good thing to have, and by being really focused, and using affordable SAFE ground testing, my belief is that we could probably develop a 25,000 lbf engine, ground test it and fly it for somewhere in the area of $3.5 billion. You also have to build the stage and overall vehicle, and put all the other hardware together. But, if the country decided to move forward, and if it were an international effort, I would think that the nuclear thermal rocket stage would be but a percentage, and not a major percentage of the total investment required. Certainly I can't see it costing as much as the SLS [the Space Launch System]. I mean, that's a big effort, over the next five years, to put together a 70 ton heavy lift launch vehicle, expandable up to hopefully 130-140 metric tons, so I think it would be in that same ballpark or possibly even less.

I certainly think that, if the country said it wanted to go ahead and do this, we could do it. I don't think the nuclear thermal rocket would be one of the key large items, because there's a lot of synergy with other technologies that would also be needed. The heavy lift launch vehicle is going to have a large liquid hydrogen tank, because the launch vehicle will use liquid oxygen and liquid hydrogen propellants. What we saw in NASA's Mars Design Reference Mission 5 study, was that the Ares V heavy lift vehicle had a large aluminum-lithium hydrogen propellant tank that was 10 meters in diameter, and 44.5 meters long. One of those tanks, cut in half, with two extra end domes, would give you the two tanks that you need for the crewed transfer vehicle to get to Mars.

A lot of the hardware that we'll be using in other transportation elements, like the heavy lift vehicle, chemical propulsion landers and ascent vehicles, are going to have pumps and nozzles as well that will also be used in the NTR. So, I think all of this parallel technology development should help to reduce the overall cost of NTR engine and vehicle devlopment.

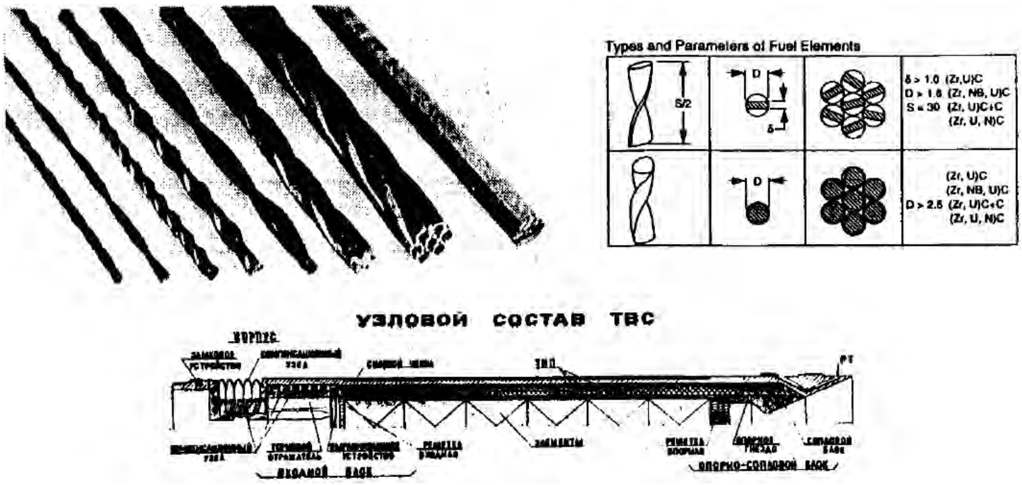
Marsha Freeman: One of the things that makes this almost an endless program, is to focus it entirely on Mars. One thing that's very interesting which you mentioned before, is that with the doubled specific impulse, you can go more quickly to Mars, and you're going to do that with people. However, the other tradeoff, is that you could use this more efficient system to deliver more cargo as well. There have been numbers of designs, Krafft Ehricke had one of them many years ago, for using a nuclear powered freighter for the Moon. What would be the applications for using NTR for the Moon?

Ultimately, I think everyone would like to see humanity build a base on the Moon, and establish a permanent human presence there. Some folks want to go to the poles, because they think there's cometary ice there, but the fact of the matter is that, when you look at all of the places you want to explore on the Moon, the pole is just one of them. There's the large crater Copernicus, along with a large number of other sites.

Focusing on the poles is almost like saying that Christopher Columbus should have gone to the North or South Pole first, and then expand outward to explore the New World! Hyper-focusing on the poles also doesn't make sense to me because the Moon is covered in minerals that have significant oxygen content.

One of the things I found most impressive, and exciting, was that on the last Apollo mission, Apollo 17, Harrison "Jack" Schmitt, our geologist-astronaut, was bouncing around the Moon near Shorty Crater, and he kicked the soil, and shouted out, "Gene! Gene! Look at this! It looks like orange soil!" And Gene Cernan said, "Nah, it's all gray here on the Moon!" But, they kicked it up, and sure enough, it was orange soil. So, they scooped up this orange soil, took it back to Earth, and it turns out that this orange soil is volcanic glass, ilmenite, with a high oxygen content. So, you can take this iron-oxide rich volcanic glass, stick it in a chemical pressure cooker with hydrogen, and reduce it, and create water vapor and oxygen.

Apollo 17 was conducted in the Taurus-Littrow Valley, which is located at the southeastern edge of the Sea of Serenity. That whole gigantic area is volcanic glass, thousands of square kilometers in extent, and estimated



NASA/Borowski

Russian designs for "twisted-ribbon" fuel elements.

to be over five meters deep. There's enough oxygen, if you process the volcanic glass there, to allow you to do 24 hour commuter flights to the Moon every day for the next thousand years or more.

Nuclear power is key to processing and reducing iron oxide-rich glass to produce oxygen on the Moon. You definitely need it, because you have 14 day lunar nights and days, so you'll need plenty of power to keep the air conditioning cooling your base during high-noon on the Moon, and at night to keep everything warm. Nuclear propulsion is also key, because you also have a significant delta-V [i.e. change in velocity required] to leave Earth orbit, to capture into lunar orbit, and then to return to Earth. That's where nuclear propulsion comes in and shows its value.Again, with a propulsion stage, and maybe an extra saddle truss and a drop tank, you can carry significant payload to the Moon, you can return stuff, but primarily you'll just want to take equipment out there to build up the base infrastructure. So, I think nuclear power for both propulsion, in-situ mining, and for maintaining a base during the 14 day-long lunar days and lunar nights, it's really the key to allowing us to get to the Moon, set up a presence there, and to maintain it.

Freeman: Years ago the Russians had a very active, well-funded and well-researched nuclear space program. That fell by the wayside, especially through the horrible years of the 1990s, and what happened to their space program. Recently, they have announced that they have restarted their program. Are you familiar with what they're doing?

Well, I'm not totally familiar with what's currently in the works. You see a lot of articles that appear in the press associated with [the Russian Space Agency] Roscosmos, and various other components of the Russian space program, talking about nuclear propulsion. They say it's an essential technology for doing human Mars exploration, but it's unclear whether they're talking about nuclear electric propulsion, or nuclear thermal propulsion. Just like in the United States, there are various national laboratories which advocate certain things, and various NASA centers advocating certain things. They've got the same kind of setup in Russia.There are institutes and research centers there, all of which have experts who are trying to advocate a particular approach. The Russians definitely have in the past worked on nuclear thermal propulsion.

In fact, we're working with the composite NERVA fuel and the CERMET, but beyond those fuels are even higher temperature fuels called ternary carbides, that consist of uranium, zirconium, niobium carbide, which have even higher operating temperatures than the composite and the CERMET. So, the Russians had been focusing on these options, and developing what they called "twisted ribbon" fuel elements that are approximately 2 mm wide and about 100 mm long, that are bundled together, and then stacking one on top of another to produce an overall larger fuel element that produces the desired amount of power for its NTR engine. I'm sure that, if they go forward with a nuclear propulsion program, they'll continue to look at this fuel option, and possibly some others that they've mentioned in the past. But, I'm sure that they'll look at nuclear electric propulsion as well. So, as part of this global space exploration initiative, maybe as we go forward, we can learn more about what everybody else is doing, and decide what the best approach is, who can bring what to bear on the initiative, and we'll see how we can go forward. Hopefully, with an affordable approach, because that's going to be the key.

Martinson: I think that's probably good, and gives a good overview of what the future potentially holds for manned space flight. Thank you very much Stan.

Peter, it's been my pleasure, thank you.

Interview: John Slough

Developing Fusion Rockets To Go to Mars

A round-trip human expedition to Mars, using current technology, would take two to three years. On such missions, astronauts would suffer deleterious health effects, including loss of both muscle and bone mass, and would be exposed to large doses of cosmic rays and solar energetic particles. The cargo required for such a mission would require 9 launches of the largest class rocket for a manned Mars mission. Professor John Slough's team of researchers at the University of Washington and MSNW, believe they have a unique solution to this problem by using nuclear fusion. The high energy density of fusion fuel means that such a rocket could reduce the trip time to 30 days, while requiring only a single rocket launch per Mars-bound spacecraft.

He was interviewed on his proposal by Jason Ross at the Fall 2012 NASA Innovative Advanced Concepts (NIAC) symposium, held Nov. 14-15, 2012 in Hampton, Virginia.

21st Century Science & Technology

Prof. John Slough (left) is interviewed at the NIAC conference by LPAC's Jason Ross.

21st Century: I was hoping you could just share with our readers a general idea of what your idea is, with your fusion rocket.

John Slough: We perceived that the problem with why we're not on Mars now, is that it costs too much, and it takes too long. So, the only way that those two problems can be addressed, is if we manage to have a rocket, where the ratio of the mass of the rocket to the power it delivers is very small. And at the same time, the exhaust velocity must be much higher than what we can achieve with chemical energy, in order to shorten the trip time.

So both of those are required to reduce the amount of material that you need to bring into space, and the time it takes to get there.

There's probably only one energy source that has that kind of energy density, if you want to call it that, and that is nuclear. And nuclear fission has been a problem for space transportation, because there, they can only use thermal energy that's derived from the fission due to the nature of the reactor/reactions itself. [But] fusion has always held the promise of being able to generate particles at very high energies, and we can then use these particles which have a very large exhaust velocity.

What we've decided is that the fusion process, can create a tremendous amount of energy, and that if it were surrounded by a different propellant, other than the fusion plasma itself, that we could transfer that energy to that material, and then achieve both the high velocity that we need for rapid transportation, and reduce the mass cost, because we actually use the propellant to compress the plasma to fusion conditions. So, we kind of do double duty there.

So the energy that's released by the fusion event goes directly into propulsive motion, rather than passing through some kind of an energy-conversion system, such as a boiling-water reactor, or a boiling-lithium reactor, or whatever you might imagine for space.

It's a very simple system. It is really kind of based on nuclear devices that were developed in the '50s for much different purposes, but the challenge was to not have high yields, like you would see in a hydrogen bomb, but to bring that down to a scale where essentially that energy could be created and transferred to the rocket ship without damage to it.

And we believe that we can do this for two reasons. One, we reduce the energy by about a factor of a billion over a hydrogen bomb—you may not even think that's quite enough, but actually it is. The other thing that's very important about the way we proceed to make the fusion event, is that we use a magnetic field to induce this lithium, the preferred material as the shell that implodes our plasma, and creates fusion conditions. We use magnetic fields to do that.

The good part of that is that after we've created this large burst of fusion energy, and transferred it to the lithium propellant, the lithium propellant becomes an ionized gas itself. And the magnetic field then guides it out the end, so that it can't restrike the rocket surface. All chemical rockets depend on the wall transmitting the impulse in the nozzle to exit in a specific direction, so here, we avoid the energy transfer to the rocket, and we protect the rocket, all done at the same time.

So, all these things coming together mean that we can now have a rocket ship mass that is, compared to the power produced, a very small number. So, we don't spend much mass in producing the energy. That's sort of the basis behind the fusion-driven rocket.

The Low-Hanging Fruit of Fusion Reactions

Okay. Let me ask you, in regards to the fusion process itself, your plan uses DT [deuterium-tritium] fusion.

That's right.

There was some talk about using helium-3 as a potential source for aneutronic fusion reactions. What are your thoughts on that, in space and here on Earth?

DT—is obviously the easiest and most energy-productive way to create fusion energy. The DT reaction has the largest cross section, has the lowest plasma temperature, so it's what I call the low-hanging fruit of all fusion reactions. And all conceptual designs for Earth-based reactors are always based on DT for that reason.

Now, helium-3 would be an interesting alternative propellant, but the problem there is, it doesn't exist naturally—it's only produced by the decay of tritium. Tritium itself is also only produced by man-made reactions, but the process that's required for making it aneutronic requires a much more difficult fuel to actually convert into fusion energy.

But having neutrons is only a problem in an Earth-based reactor, in that you need to shield it. In space, in all but the small direction that the spacecraft takes in terms of the solid angle, the neutrons just fly off into space, harmlessly.

So, neutrons aren't bad. Neutrons are actually good, in that they're volumetrically absorbed, meaning that when we try to heat our propellant, in this case the imploding shell that surrounds our plasma to bring it to the fusion condition, the whole body of that absorbs it, and so we can heat the entire mass, and that way convert it all into an ionized gas. If it were trapped in the form of charged particles, the particles themselves would be retained in the plasma, and then you have the problem of, how do you get the heat out? So, maybe for a terrestrial reactor, it might have some benefit—I'm not sure about that either. So, neutrons are good as far as I'm concerned.

Okay, so they're overly maligned.

Yes, that's right. Well, they obviously can modify and transform materials, and that is good, because that means you can create the fuel that you need, the tritium fuel, from the reaction itself. The other reason people fear neutrons is that they are the means by which a chain-reaction occurs in a fission reactor, so I think they've gotten a bad reputation from fission, but not so much from fusion. So, we'll see.

But transforming materials could be another application, using waste from fission reactors.

The Orion Project

Right. Your proposed design uses a pulse-propulsion technique similar to, say, the Orion project that was studied earlier in the U.S. What could you say about Orion as an inspiration, or about international work on nuclear rockets of this sort?

It's true: There was a lot of time and energy spent in trying to use nuclear energy in a way that they knew would produce the copious amounts of energy required for space travel. And the Orion project, unfortunately, at that time, was too close to the concept of an atomic bomb to find any widespread acceptance. In fact, it was banned by all countries.

But the main problem with fission is that, in order to get enough fissile material together to have a chain-reaction that will produce these sort of energies, it requires a very large amount of mass, and therefore a very high amount of energy release. So, the amount of energy release couldn't be reduced by a billion the way we'd like to do with the fusion reaction.

A fusion reaction can really occur at any scale, and that means it's scalable down to a level that we can use it. The only successful demonstration of fusion has been with the pulse systems, so we felt like it's got a firm grounding in the fact that at least there are several countries that know the process.

Now this is slightly different in that we intend to use a magnetic field to confine it, and that allows us technologically to make it much simpler. So, there have been studies done in other countries, in terms of the implosion technique that we intend to use with magnetic fields, particularly back in the Cold War days. So a lot of that information, I think, is now lost, because of the retirement and death of the Soviet physicists, but also, just simply, these things were not written down. But there's a great body of knowledge, worldwide, on how to maybe do this.

So, I think if we can have a demonstration of its potential, through a successful implosion, which we can do in our laboratory, that we'd probably find worldwide interest increased in this process. Because you could also use it for terrestrial energy generation.

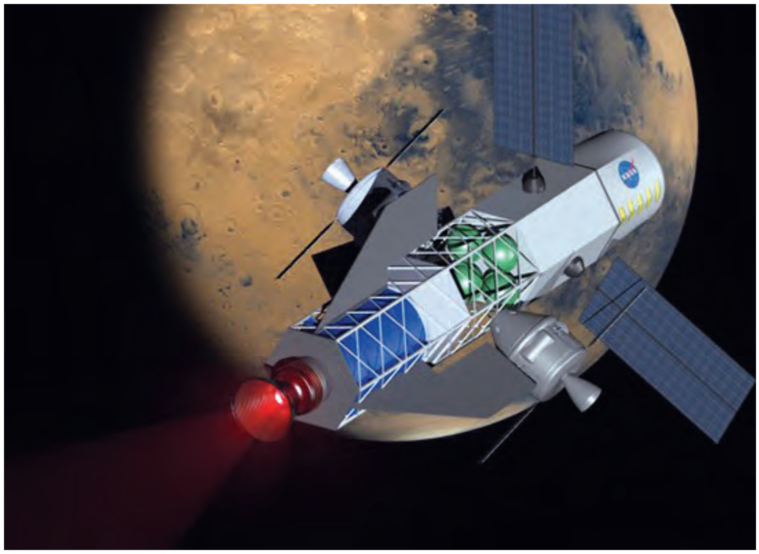
Under the Radar

Let me ask you one last thing, then. Sometimes these projects are discussed, as to whether it's a question of the scientific feasibility versus the political will, which means funding.

That's right.

Those might not actually be different questions, since scientific breakthroughs occur when you have funding, but what do you think about the political climate around all this?

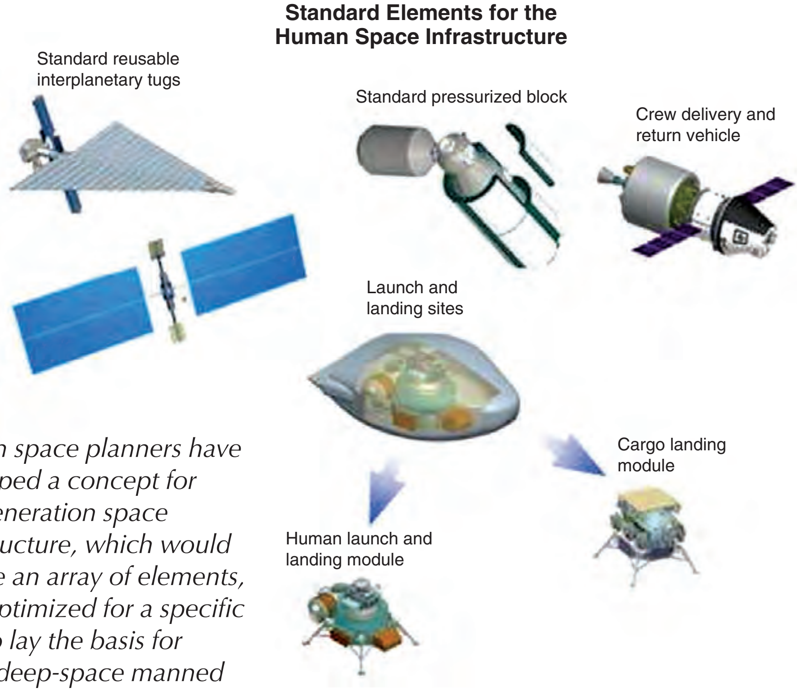
I think we're under the radar right now, in regards to what we can demonstrate. So I think that we have, fortunately, from other fusion experiments that I've conducted in the past, a large amount of equipment that we can apply to this particular task. That allows us to actually get much further along in this process. We were even thinking that we might be able to achieve breakeven, which is something that hasn't occurred yet in controlled nuclear fusion—even with a simple experiment conducted by very few people, in this manner.



MSNW

The only reason we are not on Mars now, Slough said, "is that it costs too much, and it takes too long." His firm, MSNW, is developing a fusion-powered rocket, shown here in a artist's concept, to solve that problem.

So, that part of it is fortunate for us, that we can achieve that. But obviously, future development, and particularly with the sophistication and the repeatability rating and all the other aspects of space travel, will require significant investment by NASA. But we hope we can interest the world with the fact that fusion isn't always 40 years away, and doesn't always cost $2 billion.



Russian space planners have developed a concept for next-generation space infrastructure, which would include an array of elements, each optimized for a specific task, to lay the basis for future deep-space manned and cargo missions.

Energia

INTERNATIONAL ASTRONAUTICAL CONGRESS

Space Scientists Meet Amidst Uncertainty and Hope

by Marsha Freeman

As space scientists, engineers, and program managers gathered for the annual International Astronautical Congress (IAC) during the first week in October, the global financial and economic crisis cast a pall over the creative and visionary plans put forward by representatives from more than 70 nations. The crisis, referred to by many of the national space agency representatives, has left the future of space exploration plans uncertain, especially in the United States and Europe. As if to put a point on the crisis, during the week-long Congress in Naples, Italy, a one-day transport workers strike left the more than 4,000 IAC participants scrambling for alternate ways to get to the conference.

Due to budget cutting, many of the visions and goals for future manned exploration and space science missions have narrowed. Mission planning is often circumscribed within what is considered to be "affordable," or "sustainable" (whatever that means for space exploration).

But the missions that are being carried out today are a testament to the stubborn refusal of space planners to acquiesce to the prospect that there will be no tomorrow. The International Space Station (ISS) partners are looking forward to the next goals for manned space flight, as the assembled station evolves into a base for scientific investigation and preparation for deep-space manned missions. The stunning accomplishment of NASA's Curiosity rover's landing on Mars helps to lay the basis for more extensive and intensive unmanned planetary investigation, and poses the questions for the next steps on Mars.

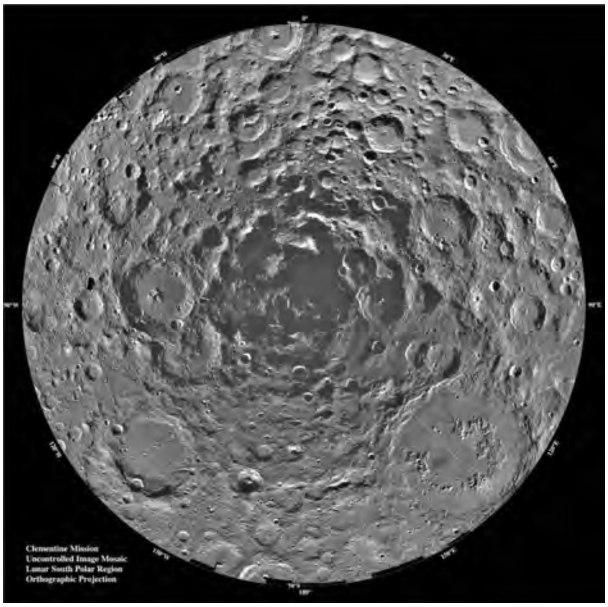
The newer space nations, particularly China and South Korea, reported on their plans to expand their range of space activities, to become major participants in global exploration. And newly emerging space nations, such as South Africa (which presented 23 papers at the Naples Congress), are, despite desperate domestic economic situations, pushing forward to use and develop space technology, with the understanding that developing such capabilities is a fundamental underpinning for real economic growth.

Even though many of even the most optimistic space planners presented new ideas and proposals with hesitation, often with the caveat: "This program has not yet been approved," participants recognize that what they do, plays an important role in *creating* the future.

Station Complete: What's Next?

Over the past year, the Herculean task of assembling the International Space Station has been largely completed, with just a few Russian modules remaining to be deployed. But the retirement of the Space Shuttle last year has left the station entirely dependent upon Russian transport, without any back-up system for the American, Russian, European, Japanese, and Canadian crew members. Now, various proposals are under consideration to develop future Earth-orbital and then deep-space transport alternatives. But the overarching question, which would determine which transportation and other infrastructure capabilities should be developed, is: "Where do you want to go?"

For the past year, the world's space-faring nations (minus China, which, thanks to the United States, is excluded) have conducted studies designed to answer that question. The near-unanimous conclusion is that the Moon should continue to be intensively studied robotically, in order to lay the basis for the exploitation of lunar resources, scientific observation, and future manned missions. The fly in the ointment has been the Obama White House, which, for no justifiable reason, has nixed lunar development as the next goal, opting instead for an imaginary manned mission to an asteroid.



NASA

The 12-mile-wide Shackleton crater, at the lunar south pole, harbors caches of water ice, in the permanently shadowed regions on the crater floor (in the center of this image). Its peaks are in near-perpetual sunlight, also making it a prime target for future lunar exploration.

At this year's IAC in Naples, challenging proposals were put forward, which take a longer view, and move from past individual, single-goal missions, to a long-term project of development of space infrastructure. Russian speakers at the Congress, in particular, outlined this approach to create the basis for a multi-decade exploration of space, rather than planning one mission at a time. It is clear to planners looking two or three decades into the future, that the next leaps forward in manned exploration of the Solar System will require an entirely new approach.

The Space Station, in order to offer the widest array of capabilities and to engage the largest number of participants, became "all things to all people," often with conflicting tasks. In Naples, Russian presentations offered a more rational approach for the future: an "open" rather than a "closed" space station architecture.

The "open architecture" approach was described in a paper by Oleg Saprykin and colleagues, from Russia's Central Research Institute of Machine Building. This Institute—abbreviated TsNiiMash—is the Russian space program's think tank, tasked with analyzing proposals and approaches for future space exploration.

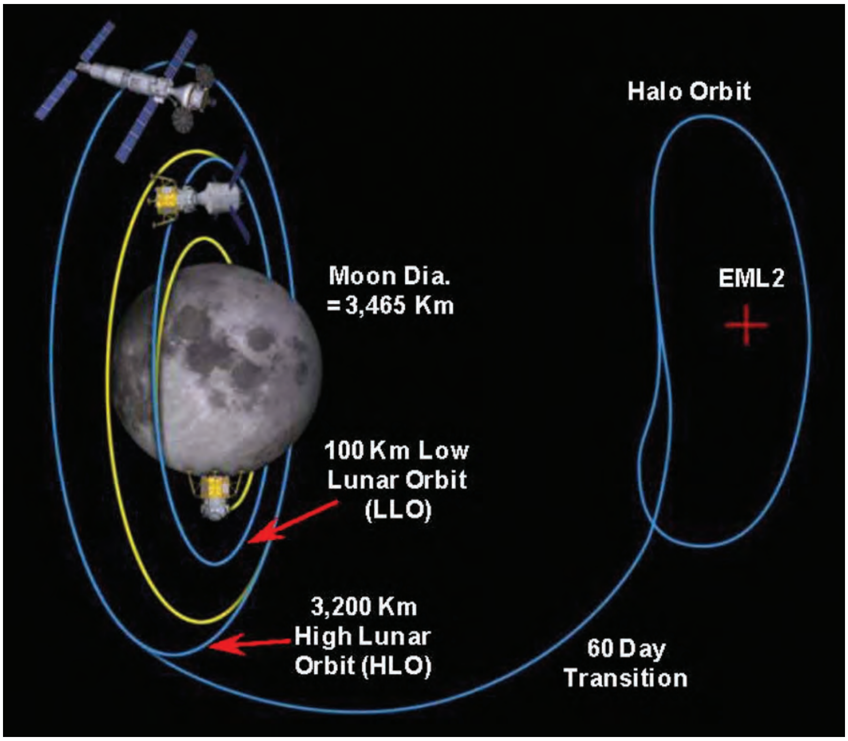
Next-generation stations must be "flexible and adaptable," TsNiiMash proposes, made up of orbital clusters of independent modules, which can be reconfigured and recombined. The value of creating specialized modules, rather than one all-purpose station, was made clear in the presentation, which showed how materials science experiments, geophysics investigations, life sciences experiments, astrophysics observations, and technology experiments carried out simultaneously, on one large facility, can pose conflicting requirements and interfere with each other on the ISS. A smaller core station, with attendant specialized modules, is more adaptable, and enables the focus of research to change with new developments.

The Time Is Now Ripe

Dr. Alexander Derechin, deputy chief designer of the S.P. Korolyov Rocket and Space Corporation Energia, also suggested in his presentation, that the replacement for the ISS, when it has reached the end of its useful life, should be, not another large, highly complex, and expensive multi-purpose facility, but a smaller base that includes a "cloud" of dedicated, autonomous, man-tended modules. Although the basic hardware would be more economically "mass produced," each module would have a specific purpose, for which it would be optimized, and could be "man-tended," rather than continuously occupied. Derechin mentioned a module for astrophysics, oriented to look out at the heavens; one for geophysical studies and remote sensing, looking down on the Earth; a module for the production of materials and biological products in microgravity, absent the disruptive vibrations caused by the movement of humans; and a module to test and verify advanced technologies.

Derechin placed his future space complex cluster in the context of what he proposes for the next 40-50 years: the continued build-up of Earth orbit infrastructure, an Earth-Moon transport system, a lunar base and the exploitation of resources, and the infrastructure to extend human missions beyond the Moon.

This approach is not new, but the time is now ripe. For the past decade, manned space exploration has centered on missions aboard the International Space Station. Now is the time to set new goals. The infrastructure described by Derechin, which he likened to the development of terrestrial infrastructure elements—roads, canals, ports, power



Boeing/NASA

Figure 1

A spacecraft that is placed in a halo orbit at the Earth-Moon Lagrange-2 point (EM L2) would need very little energy to stay in place. This region in space is about 64,000 km farther from Earth than the Moon is, and would be a low-energy transfer point to lunar orbit, as seen here.

supply networks, and communications—can, like the ISS, be deployed in low-Earth orbit.

But to set mankind on a pathway that can more efficiently service multiple decades of missions to multiple destinations, it is increasingly being proposed to locate next-generation in-space infrastructure at an Earth-Moon Lagrange point, about 64,000 km outside the Moon's orbit around the Earth. At this L2 point (**Figure 1**) gravitational forces and orbital motions between the Earth and the Moon balance each other, such that a spacecraft placed there will need very little energy to maintain what is described as a "halo" orbit.[1] From the L2 point, a spacecraft can more easily head to any deep space destination, without having to expend the energy to climb out of the gravity well from a planet's surface, or break free of a planet's orbit. Destinations could be to lunar orbit, to Mars, to an asteroid, or elsewhere in the Solar System.

In Russia, "we are close to deciding on a Lagrange point [space] station," Derechin said in his presentation. Because "we don't know yet" what the next destination will be, the "new principle for infrastructure" should be that "it is not so dependent on the task."

A Cislunar Gateway

A second paper in Naples, which Dr. Derechin co-authored with Michael Raftery from Boeing, zeroes in on a specific mission concept for lunar exploration, based on an L2 platform. The authors propose that operations in this cislunar region (between the Earth and the Moon) in the near-term, would be integrated with the existing space station infrastructure.

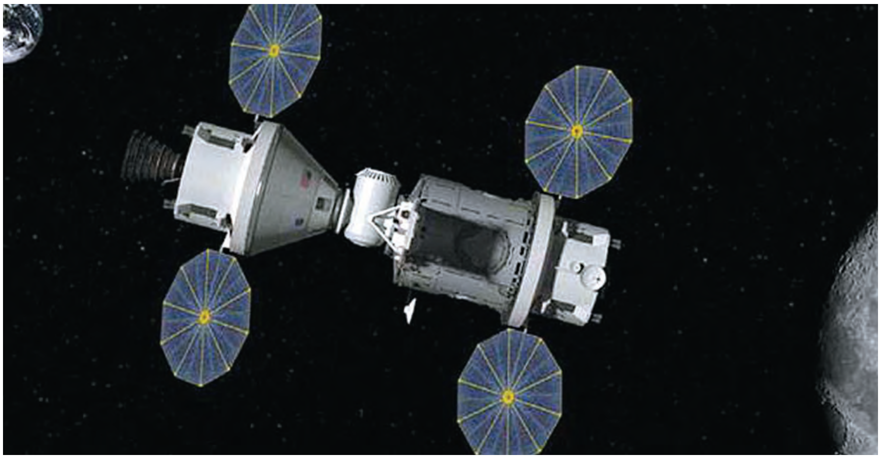
Placing space assets at the Earth-Moon L2 point has advantages over other Lagrange points, or lunar orbit. It can provide global access to the lunar surface, without restriction or limitations on landing sites. As the L2 point is positioned behind the Moon, relative to its orbit around the Earth, a platform there could be in communication with Earth from the far side (non-Earth-facing hemisphere) of the Moon. Dr. Robert Farquhar had proposed that a communications relay satellite be placed at the L2 point during the Apollo missions, so the crew would not be out of contact with Mission Control, but that was not done.

Raftery and Derechin explain that their Exploration Platform at L2 could be used as a base for a small, reusable lunar lander, which could be refueled and maintained there. The Platform, the authors suggest, could itself be moved from L2 closer to the Moon, in a high lunar orbit, from which it would deploy a surface vehicle, using less propellant for the landing system.

It is highly unlikely that crews would have long stay-times in cislunar space, as the cosmic radiation is comparable to other deep-space locations. Robotic and teleoperated robotic systems would carry out the next phase of lunar exploration, and deliver supplies to the surface, before the infrastructure were in place for manned landings.

While Lagrange point missions for exploration are under serious study in Russia, NASA has also taken a look. In Naples, NASA associate administrator, Human Exploration and Operations Directorate, Bill Gerstenmaier, commented on studies that have been done, describing the gravity "rivers" that could be followed to chart out the frontiers of exploration. Starting from a halo orbit around L2, Gerstenmaier said, an Orion manned capsule, now

1. See Dr. Robert W. Farquhar, *Fifty Years on the Space Frontier: Halo Orbits, Comets, Asteroids, and More* (2011).



NASA

Various designs are being developed to place infrastructure at the Earth-Moon L2 point. In this artist's depiction, a NASA Orion manned space capsule (left) launched from Earth, has linked up with a platform, or "gateway" facility, to be placed at the L2 point, for more efficient travel to further reaches of the Solar System.

under development, could be linked to a new kind of craft—a deep-space vehicle—which would leave the L2 port for an asteroid or Mars.

But a week earlier, NASA issued quick denials when the *Orlando Sentinel* reported the possibility that the space agency would be building a "gateway spacecraft" at the Earth-Moon L2 point as its next step in human space flight.

On Sept. 25, a NASA statement said that the agency was considering "many options" to reach the ultimate aim of sending people to Mars, adding: "We have regular meetings with OMB [Office of Management and Budget], OSTP [zero-growther John Holdren's Office of Science & Technology Policy], Congress, and other stakeholders to keep them apprised of our progress on our deep-space exploration destinations.... President Obama's current policy is to send humans to an asteroid by 2025."

A variety of unmanned, scientific spacecraft have already taken advantage of the unique characteristics of Lagrange equilibrium points between the Earth and the Moon, and the Earth and the Sun. More are planned.

As Derechin explained at the IAC, developing technologies for infrastructure-building and man-tended facilities at these Lagrange points will not be a simple matter of extending what we use in Earth orbit, but will challenge scientists and engineers to create the means, for the first time, to develop deep space.

Overall, it is important to recognize that there is no rationale to go to a Lagrange point in space as a destination. It is useful to populate it with infrastructure along a pathway to somewhere else. As with the comprehensive space infrastructure proposals on the table from Russian experts, these capabilities must be developed because there is a plan to *go* somewhere.

In the meantime, on the heels of new discoveries from ongoing missions to the Moon, more ambitious programs are being planned, to bring this nearest part of the Solar System within the domain of human activity.

Regardless of President Obama's idiotic assertion that we need not go back to the Moon, because "we've been there, done that," only a tiny percentage of the lunar orb has actually been intensively studied, and new discoveries from recent missions carried out by the U.S., Europe, China, and India have prompted a renewed thrust toward the Moon.

Learning To Land

Only the United States and the Soviet Union have successfully landed spacecraft on neighboring bodies in the Solar System. Thanks to recent scientific results indicating caches of precious water ice captured near the south pole of the Moon that are even more extensive than previously estimated, numerous nations are now planning to deliver scientific instruments to the lunar surface, to make their first *in situ* investigations. Recently, for example, an analysis of data from NASA's Lunar Reconnaissance Orbiter indicates that water ice may make up as much as 22% of the surface material in the lunar south pole Shakleton crater. Such a cache could be the raw material for chemical rocket fuel, and oxygen for future crews.

It has been known since the 1990s that permanently shadowed regions on the floor of the huge, 12-mile-wide Shakelton crater have been the collection point for water ice arriving at the Moon, most likely from comets and meteorites. This extremely cold and dark region near the south pole, therefore, has become a preferred destination for more intensive study.

The European Space Agency (ESA) has proposed a Lunar Lander project, which it hopes will be approved in November at the ESA Ministerial Council meeting. The objective is to demonstrate Europe's first soft precision landing, as a precursor mission to future human lunar exploration. Launch would be planned for the end of 2018, with a landing near the Moon's south pole. The challenges include the development of precision navigation and control to safely set the lander down in a region where it must avoid hazardous slopes, obstacles, and, because it is solar powered, shadowed areas.

The payload carried to the surface by the Lunar Lander would examine the properties of lunar dust, the plasma and electric field environment on the surface, the feasibility of making radio astronomy observations, the chemical content of the regolith (soil), and measurements of the radiation environment.

The early Soviet space program carried out a very successful robotic lunar exploration program, starting only two years after the 1957 launch of Sputnik. That history was dramatically recalled in a paper in Naples, by Prof. Vyacheslav Ivaskhin, from the Keldysh Institute of Applied Mathematics. But as scientists point out, all the data from more recent missions makes this in effect a "new" Moon, which requires more advanced high-precision landing, multiple assets operating at once, and the ability to operate under the Moon's most extreme environment.

ESM

The European Space Agency hopes to gain approval at a Ministerial Council meeting in November, to proceed with Europe's first soft landing on the Moon. Launch would be in 2018.

At the IAC in Naples, it was reported that the delayed Russian Luna-Glob project has been split into two missions, which are both under development. The failure of the Phobos-Grunt mission to Mars nearly a year ago, led to a reexamination of the upcoming lunar missions, and, according to officials from the Lavochkin Aircraft and Space Design Bureau, which designs and builds Russia's planetary spacecraft, some updating of the lunar spacecraft systems has been done. Scientists also wanted to be able to deploy more payload—up to 50 kilograms—than originally planned. Splitting the Luna-Glob program into two missions means there is more room available for experiments on each spacecraft, Roscosmos head Vladimir Popovkin explained earlier this month. The updates and changes that were made in the missions were approved by the National Academy of Sciences this Summer.

At present, the plan is for a 2015 launch for Luna-Glob 1, which will demonstrate the soft landing of a small craft, to test new technologies. It will be followed the next year by the Luna-Glob 2 mission, which will deploy an orbiter, to study the Moon from a 500 km, then 150 km, and finally a low 50 km altitude. "We must touch down on the Moon in 2015," Lavochin's director general, Viktor Khartov, told ITAR-Tass on Oct. 12. "The Phobos probe failure is a scar on all of us," he said. "We must touch down on the Moon to show ourselves that we can do it." The Moon missions have been fully funded, he stated.

The Luna-Resurs mission, scheduled for launch in 2017, will be a 200 kg "scientific station," able to drill for and analyze samples at the lunar south pole. Speaking at the third International Solar System Symposium in Moscow on Oct. 12, Popovkin and Director of the Space Research Institute of the Academy of Sciences Lev Zelyony described the Luna-Resurs as "heavily laden" and "heavily tasked." Upon touchdown on the surface, the lander will release a small Indian robotic rover.

Even in the U.S., where the Administration has downplayed the importance of the exploration of the Moon (although with some backtracking, in the face of strident criticism), new designs for small rovers are being developed, and scientists and engineers continue to develop possible future missions.

In Naples, the U.S.-Canadian RESOLVE mission was described, which is designed to land near the permanently shadowed regions of Cabeus Crater, to investigate the concentration of volatiles, such as water ice. The Regolith and Environment Science and Oxygen and Lunar Volatiles Extraction mission could be launched in 2016. The Canadian Space Agency is designing a rover for the mission, and a drill, which would be one of the scientific payload elements.

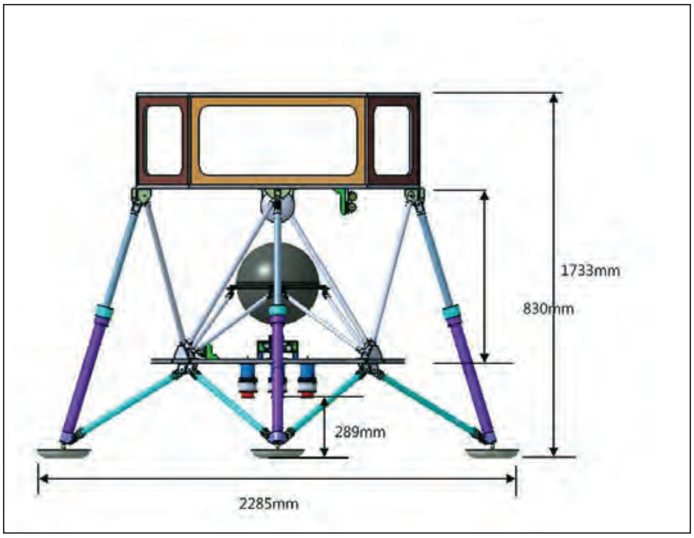
Like the lander designs proposed by ESA, RESOLVE is being designed as a solar-powered system. The rationale is that solar systems are cheaper, and because they are lighter, also reduce the weight of the spacecraft, and, therefore, the cost of launching it. The drawback is the constraint imposed, to find a sunny spot for solar recharge, when, depending upon the landing site, a rover is going to spend at least some time in darkness. William Larson, from NASA's Kennedy Space Center, explained that with solar power, the proposed mission would last only six days!

Japan and China, which have already operated spacecraft in lunar orbit, are now planning their follow-on missions which will include landers. The Chang'e 3 craft, scheduled to be launched next year, will position China as the first nation to make a soft landing on the Moon in more than 30 years. Unlike comparable missions, Chang'e 3 will include a nuclear "battery," containing plutonium 238, to provide heat and power, similar to the arrangement on NASA's Curiosity Mars rover.

Japan's SELENE 2 is under study, to also include a lander and rover, although without the advantage of nuclear isotope technology. The team from the Japan Space Exploration Agency (JAXA) which presented the SELENE-2 plans, reported that "because of the shortage of the government budget, [the] development plan [for] SELENE-2 is delayed." Even the 2017 launch schedule, they reported, "is not authorized yet."

A new entrant to lunar exploration is South Korea. Representatives from the Korea Aerospace Research Institute (KARI) reported on the conceptual design for a lunar lander demonstrator. A ground-based demonstrator has been developed to test the feasibility of basic structure and design, and landing technologies.

The timetable presented for the Korean lunar orbiter and lander is pushed out past 2020, it was reported, because a Korean rocket launcher that can lift the necessary payload is not scheduled to be ready until then.



KARI

Figure 2

The Korea Aerospace Research Institute is conducting a design study for an orbiter and lander project, and is developing a ground-based demonstrator to test the various subsystems that the project will require.

Prelude to Returning Samples from Mars

The holy grail of Mars exploration in the scientific community has been the collection of carefully selected Martian soil and rock samples, and their return to Earth. No matter how sophisticated the analytic equipment put on unmanned rovers may be, there is no substitute for subjecting pieces from Mars to the analytic capabilities of laboratories on Earth.

Until last February, the next steps in Mars exploration to culminate in a sample-return mission, were the joint European-U.S. Exo-Mars 2016 and 2018 missions. After the U.S. withdrew its participation, the missions have been reworked into a joint European mission with Russia.

In the 2020 time frame, ESA has plans to team with the Russian Space Agency, for a Lunar Polar Sample Return mission, as a precursor to a more challenging Mars Sample Return mission later that decade. This mission comes under a framework of long-term cooperation between the two space agencies, and leverages the near-term missions planned separately by each.

As described at the Naples conference, the proposed Lunar Polar Sample Return is "a very complex and ambitious mission" with many technical challenges. It is to consist of different elements, including landers, rovers, sample collection capabilities, and rocket stages to return the samples to Earth. All of these elements must be landed in close proximity to each other, and function together.

ESA will apply its experience from its 2016 and 2018 ExoMars missions, and its proposed 2018 Lunar Lander. The Russians will have completed their 2015 and 2016 Luna-Glob missions, and their 2017 Luna-Resours mission will verify many of the technologies needed for the sample-return mission, such as landing a large platform, acquiring samples, and *in situ* scientific analysis.

Where is the United States in this long-range plan?

The unconscionable cancellation of NASA's well-planned and systematic Mars exploration program was followed more recently by the Congressional stupidity of cutting NASA's travel budget. As a result, half of the scientists from the Jet Propulsion Laboratory, which manages NASA's Mars and other planetary missions, were unable to attend the Naples Congress to present their papers. Similarly, the American Astronautical Society has *cancelled* its November annual conference, because NASA officials could not obtain the funds to travel to Pasadena.

The future is created by those who can imagine it. No space mission is done in the "here and now." One of the encouraging signs at this year's international conference was that one third of the participants were under the age of 35. They will see the future.

But space exploration "during a time of austerity" can quickly become no space program at all.

This article first appeared in the Nov. 2, 2012 issue of Executive Intelligence Review *and is reprinted with permission.*

Scientists Launch a Fight To Save The U.S. Fusion Program

by Marsha Freeman

If nothing is done to reverse the proposed cuts to the U.S. fusion program, almost all of the scientists, professors, and graduate students in this photo of MIT's Alactor C-Mod tokamak will be gone when the project is shut down, this coming March.

MIT Plasma Science and Fusion Center

When the Obama Administration released its fiscal year 2013 budget proposal for the magnetic fusion energy research program a year ago, fusion scientists and many in Congress were stunned. In order to meet our obligations to the construction of the International Thermonuclear Experiment Reactor (ITER), now being built in France, the Administration proposed to hold the fusion budget approximately to last year's $400 million level, and pay for ITER by cutting $50 million from the fusion research programs in the U.S. Immediately on the chopping block are the research positions of 100 scientists who work at the MIT Alcator C-Mod tokamak, which is proposed to be shut down. Also at risk are about 10% of the researchers at the Princeton Plasma Physics Laboratory, and experiments and smaller research programs at universities across the nation. In a welcome show of unanimity, the entire fusion community has rallied to try to reverse these cuts.

That the U.S. would have to substantially increase its budget allocation, starting this year, to design and build components for ITER, has been known for years. But without an increase in total fusion funding, the White House is proposing to trade away decades of American leadership in critically important fusion research and development. In September, 63 younger fusion scientists, "under 40," sent a letter to Dr. Edmund Synakowski, Associate Director of the Office of Science at the Department of Energy, to protest this proposed policy.

"The vibrant *domestic program* must be maintained and nurtured," they wrote, "so that today's graduate students and postdocs can become experienced scientists and leaders 15 years from now," when ITER becomes fully operational. They warn that if this proposed policy is implemented, "within the next two years, hundreds of scientists and engineers at some of the premier U.S. institutions will be laid off. In the long run, this will lead to *the permanent loss of some of the brightest minds* from the U.S. plasma and fusion program…"

In response to attacks on the U.S. fusion program, both from the media and from near-sighted and demoralized scientists *outside* the fusion community, Dr. Stewart Prager, director of the Princeton Plasma Physics Laboratory, responded in comments to the *New York Times* on November 19th, explaining that fusion is "a transformative source of energy for the world." It is a "truly grand scientific challenge," with the expected result to be "a nearly ideal energy source," which will "transform our energy future." He pointed out that countries representing more than half the world's population are participating in the ITER project, to make fusion a reality.

A review of progress in fusion energy research at the annual meeting of Fusion Power Associates in Washington on December 5-6, included analyses by staff members from both the House and Senate Appropriations Committees on the Congressional outlook for the fusion budget. While the Senate has refused to increase total funding, leaving the domestic programs to the hangman's noose, in a show of pure partisan politics, the Republican-controlled House increased the total fusion funding. But those funds were taken wholly from Department of Energy "sustainable" or "green" projects, which House Members well know the Democratic-controlled Senate will never agree to.

The Congress has a choice: continue to play politics with this nation's energy and strategic future, or enable the United States to continue to play a leadership role in the global fusion development.

Lessons of the L'Aquila Earthquake Sentence

by Claudio Celani

Alessandro Giangiulio / Flickr.

After the 2009 l'Aquila earthquake in Italy, a collapsed house covers a car.

On Oct. 23, 2012, six Italian scientists and one government official were sentenced to six years imprisonment, a ban from holding public office, and a fine of 7.8 million euros plus trial expenses, for second-degree murder in the context of the earthquake that hit the Italian city of L'Aquila on April 6, 2009. The court ruled that the seven members of the Commissione Grandi Rischi (CGR) caused the deaths of 37 inhabitants and injuries to 5 others, by their issuing of an official statement one week prior to the earthquake, stating that a major earthquake was to be excluded from consideration.

World media have jumped on the juicy story, and banalized the intricate issue into a simple version: scientists have been sentenced by a court *because they have not forecast the earthquake*. Such a sensationalist report is factually untrue: the experts have been sentenced because *they did make a forecast*—the wrong one. The issue, however, becomes more intricate because of the peculiar political situation which Italy is going through, which sees a generalized collapse of political and government power, which is being replaced by a judiciary often out of control.

Another example of this is the case involving the largest steel plant in Europe, the ILVA plant in the southern Italian city of Taranto, where a court has seized the plant, arrested the management and attempted to shut down production on the basis of dubious reports on the correlation between cancer sicknesses and the steel plant emissions. The court action has jeopardized jobs for 20,000 families and threatened to shut down one-third of the entire Italian steel production, with catastrophic consequences, and was stopped only when the government issued an executive order which superseded previous provisions of law, allowing the ILVA management to restore production and fulfill a strict investment plan in environmentalist measures.

The Taranto and L'Aquila cases are only two among a large pattern of a dual power, which is tearing the country apart and which is exploited by foreign interests. On one side are a government and a parliament which, under the rule of the EU Commission and a regime of a foreign currency, the euro, have ceased to govern; on the other side, a radical faction in the judiciary exploits the justified popular rage to overthrow the representative system altogether. In the case of Taranto, this "revolutionary" mob is led by the WWF, Prince Philip's worldwide organization for deindustrialization and depopulation.

As for the L'Aquila trial as such, it was based on such shaky legal grounds that it will most probably be reversed on appeal. In fact, to sentence someone for murder, solid evidence is needed. Instead, the court accepted hearsay evidence from relatives of earthquake victims, who claim that their relatives were influenced by the CGR statement in the decision to stay at home or go back home despite the seismic wave which had been going on for months.

True, the CGR should never have made that statement. This is a matter, though, of political and scientific responsibility which demands immediate action, but which cannot effectively be addressed by court rulings. The action demanded is of the type requested by a whole group of scientists who are researching earthquake precursors, and insist that earthquakes can indeed be forecast. For instance, Prof. Pier Francesco Biagi of the Bari University, has told *Executive Intelligence Review* (EIR) that a system of two dozen satellites would be enough for a multi-parameter system to monitor earthquake precursors throughout Europe.

Unfortunately, those researchers are ostracized by the official scientific community, which claims that earthquakes cannot be forecast. They get no money while the others receive public funds. That "no forecast is possible," is the view of the six expert members of the CGR, the "top" of the Italian scientific community: Franco Barberi (a vulcanologist who has had several government jobs), Enzo Boschi (in 2009, chairman of the National Institute of Geophysics and Vulcanology), Mauro Dolce (head of the Seismic Risk Desk of the government Department of Civilian Protection), Giulio Selvaggi (director of the National Earthquake Center), Claudio Eva (professor of Geophysics at the Genua University, and Gianmichele Calvi (director of Eucentre). And yet, the "anti-forecasters" made a forecast!

The complication is that when L'Aquila was being hit by a seismic wave in the months preceding the large shock, a maverick researcher named Giampaolo Giuliani was running around announcing a major earthquake on the basis of his monitoring of radon gas emissions. The March 31 meeting of the Commissione Grandi Rischi was apparently organized by its secretary, Giampaolo De Berardinis, with the aim of issuing a "reassuring" statement. The CGR experts acted corruptly in supporting that statement.

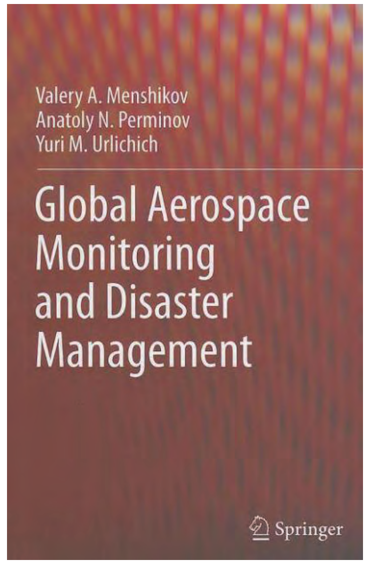
As for Giuliani, he had correctly monitored one precursor, but that is not sufficient. In fact, he had calculated that the epicenter of the earthquake would be the city of Sulmona. Had the government followed his advice and evacuated the population of Sulmona, they would have relocated to... L'Aquila!

Radon emissions are important, but not sufficient for a forecast. A forecast with a 90% probability in the case of an earthquake of magnitude 6 or greater needs a "multiparameter" approach: i.e. underground, ground and near-space precursors which include radon but also electromagnetic and other types of activities. Such parameters must be collected and evaluated by a centralized institution which can eventually decide and coordinate measures such as evacuations. Such an institution is missing and the lesson of the L'Aquila earthquake is that its creation is urgently needed.

Protecting the Planet Through International Space Cooperation

By William Jones

Global Aerospace Monitoring and Disaster Management
Valery A. Menshikov, Anatoly N. Perminov, and Yuri M.Urlichich
New York: SpringerWien, 2012
– Hardcover, 323 pp., $179



This work is a comprehensive treatment of the utilization of space assets in order to protect mankind from a variety of threats, both from the Earth and from space. At the same time it is a rallying cry for a major mobilization of all the space assets deployed by many nations in the world into a comprehensive system of protection, against threats such as earthquakes and volcanoes, as well as more long term threats such as asteroids and comets.

Mankind is often faced with major shocks coming from Nature. Recent events such as Hurricanes Sandy and Katrina, as well as the devastating tsunami that erupted in the Pacific in 2004, caught the world by surprise – and resulted in tremendous loss of life and property. By the time the population is able to see or hear the effects of the threat, it is already upon them, leaving them with no option but to seek cover – if possible – and hope for the best. And yet man's ability to "see" and "hear" such threatening phenomena has long outgrown the limited abilities of our five senses alone.

In particular, since the dawn of the space age, we have created a new space-based "sensorium" which allows us to "see" and to "hear" far beyond our limited physical sensory organs. In fact, there is not an area of the globe which is not under almost constant observation by some form of satellite capability, scanning the atmosphere, surveying the lands and the seas, and even, in the case of remote sensing satellites, penetrating beneath the surface of the Earth. In addition, there are satellites and telescopes placed to look out into the universe, at other, and more ominous threats to our planet Earth.

This book represents a comprehensive treatment of the wide variety of threats facing mankind, and outlines the various ways in which space assets can predict, possibly prevent, or at least reduce the damage wrought by all types of natural catastrophes, whether from the Earth or from the skies. The authors, Anatoly Perminov, Valery Menshikov, and Yuri Urlichich, are all key players in the project which the book is promoting, the International Global Monitoring Aeropspace System (IGMASS) project. Anatoly Perminov is the former head of Roskosmos, the Russian space agency; Yuri Urlichich is the Designer General of the Russian GLONASS, Global Space Navigation System; and Valery Menshikov is the chairman and chief promoter of the IGMASS project and the vice-chairman of the K. E. Tsiolkovsky Academy of Cosmonautics. While the project has been initiated primarily by Russian and Ukrainian space scientists within the context of the UN and international space organizations, and has its origin in the specific Russian experience in space exploration and space utilization, its realization is of importance for all Mankind.

Space has affected every nation on Earth. Even the poorest nations in Africa or Asia are supported by satellite communications or satellite monitoring. While the actual space-faring nations are still limited in number (although the number is growing), there is hardly a nation on the face of the Earth that has not become a space-{using} nation.

And yet these capabilities remain largely limited to the needs and the requirements of their purchasers or end-users. If they were brought together into a single collaborative network, they would represent a capability for mankind which would be far more powerful than the simple sum of its parts.

The goal of the IGMASS project is to convince the various space-faring nations of the need to bring together their capabilities into a coordinated network. As the introduction to the book states: "The creation of a viable international mechanism for efficient forecasting and early warning against dangerous natural and man-made phenomena that pose planetary-scope danger is high on the agenda. It is time to seriously state that modern and maximum efficient warning against impending emergencies of space, of natural or artificial origin, can be provided only on the basis of large-scale international projects with complex, coordinated, and rational use of the scientific and technical potential of all countries of the world."

The book is divided into chapters, dealing respectively with the various types of threats facing mankind and the means by which space can be utilized in dealing with them.

Peter Haeussler , U.S. Geological Survey

Denali Fault: Susitna Glacier. Patty Craw, DGGS, stands in front of the Susitna Glacier thrust fault. The November 3 earthquake started with an M7.2 earthquake along this fault in Alaska, USA on Nov 10 2002.

First, there are the natural calamities: earthquakes, volcanoes, floods, hurricanes, and the like. The latest research by Russian scientists has long noted that changes in the ionosphere precede burgeoning earthquakes by some time, giving the possibility of a longer lead time for affected populations to prepare themselves for what is to come. (see "Are Eathquakes Forseeable? The Current State of Research," by Sergey Pulinets, {EIR}, August 5, 2011). While earthquakes and volcanic eruptions are typically consigned to the lower geosphere, changes in the Earth's crust bring about early changes in the Earth's atmosphere: release of characteristic gases, changes in the electromagnetic fields, changes in the ionospheric plasma, proton, and high-energy electron precipitation in the upper atmosphere – all of which can be monitored from space. And it has been statistically confirmed, the authors note, that such ionospheric anomalies occur on average five days before a seismic shock, a relatively long lead-time to prepare for an earthquake. While such calamities as earthquakes and volcanic eruptions cannot at the present time be controlled by man, with the aid of heightened level of monitoring precursors, losses can be brought down to a minimum. The difference can be dramatic. The authors relate two different incidents of earthquakes in China to make their point.

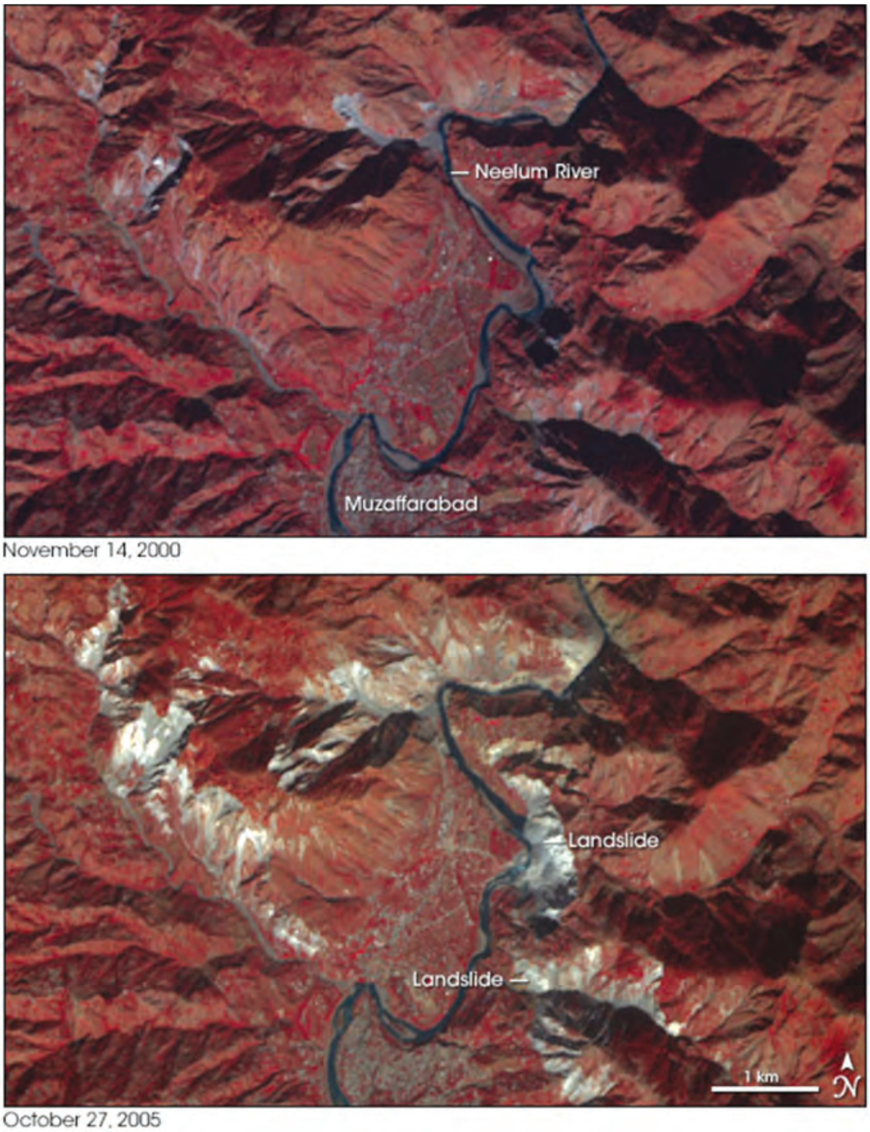
In 1975 when Chinese seismologists sounded the alert about a possible earthquake in the area of Haichen, the population was evacuated. One evacuation, carried out two hours before a nine-point earthquake, saved thousands of lives. A year later, scientists, concerned about several earlier alarms they had issued that turned out to be false alarms on signs of a pending earthquake, refused to issue an alert for the city of Tangshan, with a population of 1.3 million. The earthquake that did eventually ensue killed hundreds of thousands of people.

Within the community of seismologists, there are still many who deny the possibility of predicting earthquakes by means of ionospheric changes in spite of the strong evidence presented by the physicists studying the ionosphere. (see "The Emerging Science of Earthquake Prediction," by Oyang Teng, *21st Century Science & Technology*, Winter 2011-2012). This has presented a serious obstacle to the needed collaboration between these two important groups of scientists. These spurious arguments have also been buttressed by the minions of Prince Philip's environmentalist movement, which has as its leitmotiv the Malthusian axiom that "natural catastrophes" should not be interfered with by man since they help to "cull the herd" of the human population.

While the impetus for the IGMASS project has primarily emanated from Russian and Ukrainian scientists, the data that they have accumulated with regard to natural calamities, while limited largely to studies on the Eurasian landmass and adjacent maritime areas, is quite persuasive – and wide-ranging. This is not surprising, given the fact that the Eurasian land-mass and the Pacific Ocean seas are the location of well over half of the world's major natural disasters.

The second chapter of the book deals with calamities caused by human error, so-called technogenic emergencies. These also include accidents resulting from lack of foresight regarding possible "unintended consequences" when planning industrial or infrastructural projects. According to the United Nations, such disasters rank third in the number of casualties, just trailing behind natural calamities caused by weather or geological factors. Again, not surprisingly, these are concentrated in the less developed areas of the world, in countries of Asia and Africa, where the austerity policies imposed upon these nations have limited their ability to adequately develop their technology.

Many of these types of disasters, which the book gives as examples, such as the explosion at a Union Carbide plant in Bhopal, India in 1984, which killed more than 4,000 people and poisoned over 40,000, are simply the result of human error – or pure negligence. In some cases they are simply the result of the attempt to continue using a specific technology beyond the useful life of its operation, without modernizing the technology.



NASA

Area surrounding Muzffarabad Pakistan before and after the 2005 earthquake.

They are difficult to predict or and the use of aerospace assets may seem somewhat limited in dealing with them.

Nevertheless, space assets can also play a major role in monitoring and detecting looming problems. Russia has begun to use its aerospace capabilities in order to monitor their extensive system of gas and oil pipelines. Russia's Gazprom has developed a system of monitoring its arctic oil-gas field at Yamburg, which utilizes Russia's space assets. As noted by the authors: "Gazprom has lately created and been actively testing a pipeline aerospace monitoring system on the basis of existing and future remote earth sensing spacecraft as well as unmanned aerial vehicles. The system is designed to detect sections of trunk gas pipelines laid at a smaller depth than necessary, and would monitor the conditions of gas pipelines, engineering systems and other facilities such as dykes, surface sections, water crossings, transport routes, etc."

In addition to such dramatic phenomena as earthquakes and volcanoes, there are smaller and less dramatic geological movements which can also wreak havoc on human infrastructure. These involve cyclic geodynamic movements or displacement of the Earth's crust. In particular, in areas where there is extensive mining, this activity can cause subtle shifts in the Earth's crust surrounding it which are strong enough to disrupt structures built upon it.

In Russia, this is particularly true in the Ural Mountain region, a major mining area for Russian minerals. The Mining Institute of the Urals Branch of the Russian Academy of Sciences already utilizes Global Positioning System (GPS) surveying equipment that can monitor crustal deformations caused by the impact of mining operations.

Another type of crustal movement that can seriously disrupt man-made engineering systems and infrastructure is the phenomenon know as "planetary pulsation." This occurs exclusively in areas of tectonic faulting. Although the variations of the "pulse" involve relatively small frequencies, they can have an impact on any vertical construction (posts, supports, etc.) causing them to incline toward the center of the stress zone. Such stresses can be detected through space-based geodetic monitoring.

Most of the Russian ministries utilize some form of space-based assets for monitoring their operations, but the IGMASS program calls for an extensive upgrading of these capabilities. "The Russian Federal Space Program," our authors write, "calls for developing national remote earth sensing system up to 2015, including the creation and/or development of certain space assets that can jointly monitor natural calamities and technogenic disasters. These include remote sensing and monitoring, navigation and hydrometeorology, communications and relay systems. All of these space systems should, despite their departmental disunity, constantly interact with each other through ground-based infrastructure designed for controlling space missions and for receiving, processing, and distributing space data."

The ability to place the satellites into orbit which are needed to build a global system of this nature is made possible by the existence of the three major navigation systems, the Russian Global Navigations Satellite System (GLONASS), the U.S. Global Positioning System and the European GALILEO system, which would allow the prompt positioning of mobile objects, such as microsatellites, to accomplish the needed geodetic surveying of a region in order to detect even minor geological shifts that might affect human life and production.

The book's third section outlines the more ominous threats to the Earth from space objects that could destroy human life on the planet. Far from being an object of science fiction or a fantasy of some Hollywood producer's attempt to titillate a gullible audience, the threat from space objects is very real and getting closer by the day.

As the authors note, the Earth has been struck by asteroids and comets (Near-Earth Objects, NEOs) many times throughout its history, sometimes with absolutely devastating effects as in the one 65 million years ago that caused the disappearance of the dinosaurs. But this is not ancient history. It is the nature of the universe in which we live. As recently as October, 2009, an unobserved asteroid approaching the Earth exploded in the upper atmosphere at a height of 15-20 km directly over South Sulawesi province in Indonesia. NASA estimated that it entered the atmosphere at a speed of more than 20 km/s, realizing an energy of 50,000 tons TNT equivalent, or three times more powerful than the Hiroshima atomic bomb. Our ability to deal with such threats is determined solely by our space capabilities, both to detect and to monitor the movement of such threatening objects, and, at a certain point, to deflect them from any trajectory headed our way, or to destroy them in flight. Here we're dealing with a somewhat more complicated dilemma, as coping with NEOs requires discovering the threatening bodies and then determining - with a good degree of accuracy - the orbit of the body and its physical properties.

The authors note that, at the time of their writing, the total population of NEOs larger than 1 km in diameter was estimated to be between 1,000 and 1,200. As of December 18, 2008, a total of 5,901 NEOs had been discovered, with 761 of these approximately 1 km or larger in diameter. In addition, 1,004 NEOs had been classified as Potentially Hazardous Asteroids, based on the asteroid's potential to make threatening approaches to the Earth. Much public attention has been given to the asteroid Apophis, which is predicted to approach close to Earth by 2029 and could hit Earth by 2036.

Chapter 3 gives a summary description of the dangers presented by these Near Earth Objects and the various ways in which those deadly collisions with such asteroids can be avoided. If the dangerous space object is over 7.6 million kilometers away from Earth, detection is accomplished by powerful optical telescopes. If the object comes closer, radio telescopes can be used to track its movement.

According to the Russian scientists, a dangerous space object must be either shifted from its trajectory or disintegrated into small fragments. This could be done, using what they describe as kinetic star-shaped penetrators or, in some cases, a nuclear explosive device.

The final chapter outlines a program for creating a Planetary Defense System against such threats. The authors envision that the technologies now available to mankind would be sufficient to create a coordinated system. In addition, there already exist in the various national programs, or collaborative programs among nations, much of the technology that would provide the basis for such a system. The authors do not see IGMASS as an alternative to those already existing operations, but rather as a forum for bringing together those capabilities into a global coordinated network.

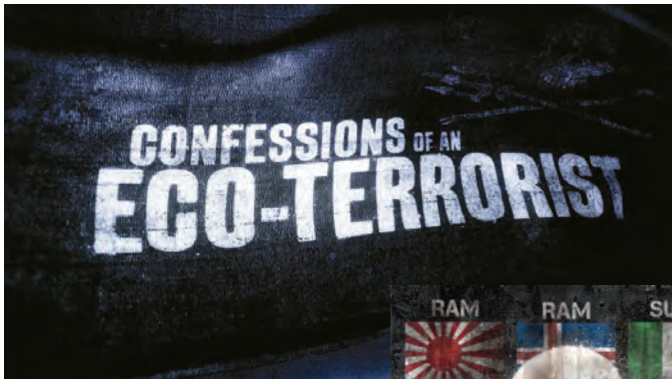
The big problem is getting the various space-faring and space-utilizing nations to cooperate on that level. While the initiative has come from a group of Russian and Ukrainian scientists and is making some headway among many other nations, NASA has been singularly absent from involvement in the project, although by no means oblivious to the danger. In 2012, NASA set up, under the Jet Propulsion Laboratory, an NEO Office, tasked with the responsibility to map out the various threats on the horizon. And, as the authors of the IGMASS book indicate, the NASA capabilities in this respect are absolutely essential in elaborating a global defense system. This importance has only been enhanced by the recent success with the deployment of the Curiosity rover on Mars by NASA scientists. As statesman and economist Lyndon LaRouche has noted, this has opened a new chapter in our space exploration capabilities. Curiosity now shows that our ability to "see" and "hear" can now be accomplished from other planetary bodies, perhaps better situated to detect potential dangers. While there is extensive cooperation between the U.S. and Russia in space, the NEO issue has not been taken seriously enough to bring about the needed cooperation in this effort.

But the looming danger facing humanity, which will become even more apparent as some of these space objects begin to approach our Earth, must serve to overcome the psychological barriers that still remain preventing mankind from taking that "giant leap" toward a system of defense against the threats that now face us all.

Confession: The New Public Relations Tool

by Gregory Murphy

Confessions of an Eco-Terrorist
Peter Brown, Director
The Little Film Company, 2011
90 minutes, DVD, $25



The intriguing title of Peter Brown's film made me look forward to a film that would tell the secrets of the eco-terrorists, in much the same way John Perkins' book *Confessions of an Economic Hit Man* revealed some of the inner secrets of international finance. I did enjoy the film, but was disappointed to find out that it wasn't what I expected. The word "confession" in the title gives the viewer a sense that they would let in on some of the best-kept secrets of the environmental movement. This film falls short in this respect, and would be better named Remembrances of an Eco-Terrorist. With that being said, the film provides a good inside look at the Sea Shepherds Conservation Society, including a sometimes humorous approach to story-telling.

Courtesy of the Little Film Company

Peter Brown, director

Inside the Sea Shepherds

While the film goes behind the public image of the Sea Shepherds, it omits several very important facts about the organization. One glaring omission regards the background of Sea Shepherds leader Paul Watson. He was one of the original founders of Greenpeace and was thrown out for being too radical in their view. Another major omission in the film, was the failure to name the person responsible for the sinking of two whaling ships in Iceland in 1986. This event is mentioned in the beginning of the film as a teaser, but Peter Brown, the director and story teller, says he knows who was responsible, while failing to inform his viewers of the person's identity. This is one of the points of the film that I found troubling.

Although Brown didn't say who the reasonable party was, a quick search of the internet shows that the person who committed this blatant act of eco-terror is Ron Coronado, who joined the Sea Shepherds in 1986, but went on to become the national spokesman for the Earth Liberation Front (ELF), which was originally founded in Great Britain in 1992. The ELF works in decentralized units that commit acts of eco-terror against animal testing facilities and the logging industry.

The other point of the film that I found troubling was the lack of focus on the Malthusian outlook of the environmental movement. Paul Watson has a patently anti-human outlook. In 1977, while trying to save a whale

Courtesy of the Little Film Company

In a still from the movie, director Peter Brown (right) looks on as Captain Paul Watson speaks onboard a Sea Shepherds ship

from a Russian whaling vessel, he claims to have seen pity in the whale's eye, and from that point, decided that he would devote himself to saving marine life, and not concern himself with the plight of human beings. His crusade to "save" the oceans has led him to make such groundless claims as that the Russians were whaling not for the meat, but to use the blubber to form a necessary high-viscosity lubricant in ICBMs.

The film showcases several instances where the Sea Shepherds manipulate the media that flock around them. One such scene shows the crew of the Sea Shepherd ship firing off a flare and running around acting as though they are under attack for the sole purpose of producing television footage. Brown says in the film that the purpose of all of this needless action is to produce "mind bombs for the media." That phrase alone can be used to describe the totality of the film.

After viewing the film, this author spoke with the film's director, Peter Brown, who described his film as a collection of his memories with the Sea Shepherds. He said that he wanted to use his experiences as a way to highlight for the public how the environmental movement operates. This is important given the fact that most of the public is unaware of the tactics of the environmental movement, and is only familiar with the Sea Shepherds from their Animal Planet reality TV show "Whale Wars," which showcases their ongoing battles with the Japanese whaling fleet in the Southern Ocean around Antarctica.

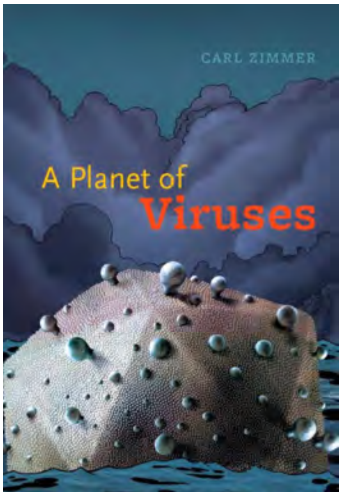
Brown also talked more about his views on the green movement, saying that he believed that "the green movement has to have a new paradigm and that it must include nuclear power." In this, he joins other green campaigners, for example, the green commentator for the Fabian Society Mark Lynas and former Greenpeace Founder Patrick Moore. Brown further stated that he also believes that as part of the new paradigm, the greens must move beyond fighting to save seals and stop whaling since these fights are locked in the past and only good for fundraising.

I would recommend this film to anyone interested in the green movement but to be prepared to watch with a critical eye and not be overcome by the heartbreaking scenes of butchering of seals and whales.

Viruses for Everyone

By Liona Fan-Chiang

A Planet of Viruses
Carl Zimmer
Chicago, Illinois: University of Chicago Press, 2012
Paperback, 109 pp., $12



The intricacies of what is to most of us a mysterious land, such as the world of viruses, is not easy to communicate without sometimes either generalizing the details or writing a tome. Carl Zimmer managed to avoid both while making the various facets of the study of viruses accessible to any amateur. A Planet of Viruses is a collection of short essays written for the World of Viruses project as part of a Science Education Partnership Award from the National Center for Research Resources at the National Institutes of Health. The World of Viruses project (worldofviruses.unl.edu) was created to help people learn more about viruses and virology research through various mediums such as radio documentaries and short stories.

Zimmer traces out the captivating paradoxes which have driven scientists to the several stages of discovery of this field of study. Through this history, the reader will see that viruses are not something one only encounters when they cause disease, but are in fact everywhere, in healthy organisms, in antarctic ice and in caves where no life can be found. We read: "On average, each person has 174 species of viruses in the lungs." In fact, Zimmer, in this little book, has taken on just enough of the subject matter to dispel many commonly held beliefs about viruses, including that disease is necessarily caused by transmission of a virus, that they are always dangerous, and that they are foreign to life. For example, he cites the crucial role of viruses in the evolution of the mammalian placenta, and makes the case that viruses are so much a part of, and possibly a driver of, the evolutionary process, that it is so hard to tell what is "original" DNA and what is "virus," that viruses may have to be considered part of our identity. This is similar to what we continue to discover about microbes, namely, that of the 100 trillion cells in the human body, only about 10% of these are not bacteria, viruses, or other organisms, posing the question: what parts do we consider "human"?

Zimmer goes into enough detail about the unique characteristics of the most famous viruses such as the viruses associated with the "uncommon" cold, the flu, SARS, HIV, West Nile Virus, as well as common but not so famous ones, to make these mysterious and often frightening diseases more knowable, less a subject of fear and more a subject of study.

Everyone should have some basic knowledge of the rudiments of what viruses are, if not for the practical reason that we live with them every day, then for the many implications their variety of curious characteristics suggest. For example, while delineating the sharp distinction between the living, inert and bio-inert, Vladimir Vernadsky, the founder of biogeochemistry, points out a that viruses alone seem to elude categorization, bridging the boundary between the living and the non-living. They seem to consist of too little to be living, and yet they actively instigate their own reproduction.

Yet another big question comes from their sensitivity to radiation, for example deactivating into a benign form from UV solar radiation. This raises the question of whether these very influential forces of life have been a conduit for other types of cosmic radiation and flux. There, of course is the better-known case, which Zimmer also cites, of the role of viruses in photosynthesis, but what about their role in other dramatic periods such as the great extinctions, which have been correlated to larger galactic cycles. (footnote – Planetary Defense: An Extraterrestrial Imperative, larouchepac.com)

Above all, as suggested by Zimmer, what will we learn about life, the biosphere, ourselves, and possibly the cosmos, once we come to understand and wield this powerful force of nature?

Books Received

Louder Than Words: The New Science of How the Mind Makes Meaning, by Benjamin K. Bergen. New York, New York: Basic Books, 2012. Hardcover, 312 pp., $27.99

National Geographic Tales of the Weird: Unbelievable True Stories, edited by David Braun. Washington, DC: National Geographic, 2012. Paperback, 543 pp., $18.95

Forgotten Civilization: The Role of Solar Outbursts in our Past and Future, by Robert M. Schoch. Rochester, Vermont: Inner Traditions, 2012. Paperback, 355 pp., $18.95

HIGGS: The Invention and Discovery of the `God Particle,' by Jim Baggott. New York, New York: Oxford University Press, 2012. Hardcover, 304 pp., $24.95

The Ravenous Brain: How the New Science of Consciousness Explains our Insatiable Search for Meaning, by Daniel Bor. New York, New York: Basic Books, 2012. Hardcover, 352 pp., $27.99

Forgotten Worlds: From Atlantis to the X-Woman of Siberia and the Hobbits of Flores, by Patrick Chouinard. Rochester, Vermont: Park Street Press, 2012. Paperback, 288 pp., $20.00

The Goldilocks Planet: The 4 Billion Year Story of Earth's Climate, by Jan Zalasiewicz and Mark Williams. New York, New York: Oxford University Press. 2012. Hardcover, 256 pp., $29.95

Run, Swim, Throw, Cheat: The Science Behind Drugs in Sports, by Chris Cooper. New York, New York: Oxford University Press, 2012. Hardcover, 288 pp., $29.95

How We Think: Digital Media and Contemporary Technogenesis, by N. Katherine Hayles. Chicago, Illinois: The University of Chicago Press, 2012. Paperback, 280 pp., $25.00

Alan M. Turing, Centenary Edition, by Sara Turing. New York, New York: Cambridge University Press, 2012. Hardcover, 169 pp., $29.99

Moral Origins: The Evolution of Virtue, Altruism, and Shame, by Christopher Beohm. New York, New York: Basic Books, 2012. Hardcover, 432 pp., $33.50

Ballparking: Practical Math for Impractical Sports Questions, by Aaron Santos. Philadelphia, Pennsylvania: Running Press, 2012. Paperback, 208 pp., $15.00

Rooster of the Apocalypse: How the Junk Science of Global Warming Nearly Bankrupted the Western World, by Rael Jean Isaac. Chicago, Illinois: The Heartland Institute, 2012. Paperback, 113 pp., $16.95

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