PART FOUR

I think it's important to have a basic understanding of nano technology and its history. The technology dates back to the 1950s and energetic compounds date back to the 1940s. Nuclear power and nuclear demolition also date to the early 1940s and the industries involved in the development of nuclear weapons are and always were active in experimenting with and developing new nuclear demolition technology. No less active, and in fact far more active, than those developing nano-energetic compounds. Nano-technology was started by the nuclear industry. The nuclear industry is, like the nano-tech industry, an industry involved in molecules. It only makes sense that nano-tech started in the nuclear industry and that's because it did. Yet the average person doesn't know this. Advances in nuclear technology are simply more difficult to fully understand because there is far less published material in that area of scientific development and improvements. Yet there's more than enough to be deeply concerned for out future.

UNDERSTANDING

MINIATURIZATION
AND

NANO TECHNOLOGY

NANO-TECHNOLOGY IN 1959

It's critically important that we examine nano-technology prior to 2001 and obtain an understanding of where the field started, what years were involved in its birth and what the philosophies of our entrance into this fascinating new nano-era were. Let's examine nano-tech from the beginning so we might, perhaps, gain a better understanding of where energetic compounds began, where they were in 2001 and what applications nano-technology might have as they would apply to nuclear devices designed for demolition and destruction during the same period of frenzied nano-tech experimentation.

Richard P. Feynman

Nanotechnology has bridged science fiction and fact ever since it was first conceptualized in 1959. That was when renowned physicist Richard P. Feynman speculated in a lecture entitled "*There's Plenty of Room At the Bottom*" that it would be possible to assemble the tiniest structures atom by atom by the year 2000. Of course he was wrong; it happened years sooner.

Feynman proved to be prescient. Today there are many examples that nanotechnology – "*the assembly of products on a molecular level that can be measured in less than 100 nanometers, where a nanometer is a billionth of a meter –* " is a real technology that is generating revenues for companies across the globe. Materials that have been painstakingly engineered on the molecular level are springing up everywhere. Cosmetics maker L'Oreal uses tiny "*nanocapsules*" to deliver skin-healing chemicals in its Lancome lotions so that they sink much deeper into the skin. Of course on a cellular level those nano-particles might be doing far more harm than good. General Motors has crafted composite materials that make stronger and lighter fenders for its sports utility vehicles. And Levi Strauss has used nanomaterials from Nano-Tex LLC to weave teflon within fabric to create stain-resistant Levi's Dockers pants. Wilson Sporting Goods used nanotechnology materials to make a better golf ball. And the military industrial complex has been making nuclear apples.

"*This is happening much faster than I thought,*" said Stan Williams, a research fellow at Hewlett-Packard. "*I keep telling people that nanotechnology won't occur in a nanosecond. I never could have believed three years ago that we would be where we are now.*"

By the year 2001, when the events of 911 were thrust upon us, nano-technology was no longer in its infancy but rather, it was a burgeoning field of study involving everything from constructing living nano-products to nano-tech in the nuclear industry. Nano-tech became all-pervasive with immediacy and it was applied to all technologies across the public and private, commercial, industrial, medical, manufacturing and technological world we lived in then; the same world we live in today. Science operates at a consistent frenzy for everything "*new*".

The broader public views nanotechnology without even a basic understanding yet with a mixture of hope and fear. As far back as the 1980s, nanotechnology pioneer Eric Drexler, author of "Engines of Creation," speculated about the fears and hopes of the technology. He hoped that nanotechnology would result in the ability to create tiny machines that could assemble any scarce commodities such as food or precious metals, eliminating the need in the long run for humans to do any work. Yet he also feared "*engines of destruction*" could be created. The quest to create nanoweapons, he thought, might result in tiny machines that could wreak havoc on a molecular level and turn the world into a "gray goo." Bill Joy, a co-founder of Sun Microsystems, raised the public fear of nanotechnology higher in an article in the April, 2000, issue of Wired. The article, entitled, "Why The Future Doesn't Need Us," argued that the pace of innovation in nanotechnology would eventually be a threat to the future of the human race. And in 2002, Michael Crichton's novel Prey brought the fears home in a story about micro-robots escaping from a lab. The thought of nano-nuclear technology in 2001 becomes more appealing ... no?

Meanwhile, nanotechnology became real. In 1989, IBM researcher Don Eigler was able to use a scanning tunneling microscope to create the letters "IBM" by moving around atoms. In 1991, Japanese scientist Sumio Iijima discovered carbon nanotubes, a structure that could be used to build the tiniest electrical wires.

In 2000, President Bill Clinton authorized a major nanotechnology initiative to ensure that the U.S. would compete with other nations. Funding has grown to $982 million a year. The state of New York is offering incentives for companies to join its nanotechnology center of excellence in the Albany region. Other countries in Europe and Asia are also pouring huge resources into nanotechnology initiatives. The National Science Foundation predicted that the worldwide market for nanotechnology products and services could be a $1 trillion industry by 2015.

Good or bad, nanotechnology is moving forward. Sometimes the result is disappointing. Nanosys, a nanotechnology start-up in Palo Alto, Calif., tried to raise $106 million last year in an initial public offering, but investors shied away from the deal because Nanosys had little revenue and was losing money. The company pulled the IPO in August, 2004, and decided to rely upon private capital for the time being.

But as the aforementioned examples of commercial research show, nanotechnology has moved well beyond the federal national laboratories and universities where initial research started decades ago. But how soon nanotechnology really pays off depends on how you define it. Robert Morris, the recently retired director of the IBM Almaden Research Center in San Jose, Calif., considers some of the current commercial uses to be more like designer chemistry than true nanotechnology applied to information technology. Nanotechnology manufacturing isn't expected to replace traditional methods for making silicon chips until 2013 to 2019, according to Ken David, director of computer research at Intel's technology and manufacturing group. And there is still a long way to go before the real payoff of nanotechnology materializes in nanocomputers that are assembled on the molecular level. Researchers say it will be some time before experiments in exotic devices using "*quantum computing*" become commercial products.

Beyond the mainstream applications of nanotechnology, scientists like Williams expect that nanotechnology will ultimately become useful in information technology applications. Among the companies working on IT nanotechnology are IBM, Motorola, HP, Lucent, and Hitachi. Their work isn't finished, but it still shows promise, said Mark Ratner, a professor of chemistry at Northwestern University and author of "*A Gentle Guide to Nanotechnology*." National labs such as Sandia, Oak Ridge, Argonne, Lawrence Berkeley and Lawrence Livermore are also hard at work on nanotechnology. Among the projects are efforts to create an artificial retina, nanoscale microchips, and replacements for a range of electronic devices from light-emitting diodes to nano computers.

On the nanotechnology manufacturing front, one early application is in the creation of new tools for making chips and displays. Researchers also foresee basic advances in memory chips that hold much more data than today's flash memory chips as well as new kinds of sensors that can be built into any kind of device. While some of the manufacturing tools are available now, many of the information technology applications will take some years to get to the market.

"*If you're talking about a complete nano computer made from the ground up, we're talking a very long term project,*" said Meyya Meyyappan, director of the Center for Nanotechnology at the NASA/Ames Research Center in Mountain View, Calif. "*Other markets are near term, but information technology falls into the long-term category.*"

Still, the characteristics of materials that are created atom by atom, or from the bottom up, rather than chiseled down from larger materials in a "*top down*" fashion, could be breathtaking, Meyyappan said. He notes that carbon nanotubes can withstand 1,000 times more heat than the copper wire now used in chips. Carbon nanotubes assemble themselves like spaghetti noodles at the moment, but if researchers figure out how to make the nanotubes connect exactly where they want, they will be able to use them in mass-produced electronic devices.

Storage devices could also benefit from nanotechnology; in some sense, the giant magnetoresistive heads for hard disk drives already operate in the nano world because they involve manipulation of magnets on a nanometer scale. But further out are devices that employ nano structures such as IBM's Millipede, which could allow a storage device to use a thousand read/write heads instead of just one, Morris said.

All of this technology innovation has been a long time coming. Consider the case of Applied Nanotech, a small company with 20 employees in Austin, Texas, that was first incorporated to pursue nanotechnology in 1987. A subsidiary of Nano-Proprietary, Applied Nanotech went public in 1993 and obtained more than 40 patents on nanotechnology. Applied Nanotech plans to use carbon nanotubes to create better field emission displays for flat panel television sets. The company has been working for seven years to develop the technology and license it to a large consumer electronics manufacturer. The technology uses carbon nanotubes to emit electrons which in turn can be used to create a much brighter display that uses less energy than conventional liquid crystal or plasma displays.

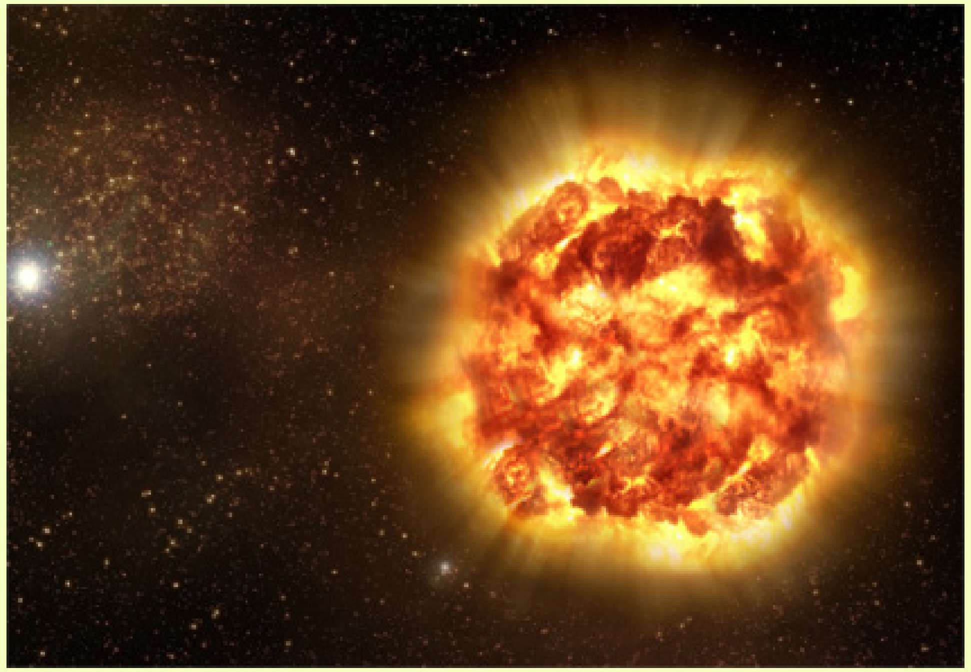
Another promising area is nanoimprinting, which seeks to replace traditional photolithography in the manufacture of semiconductors. Nanoimprinting gets its name from the fact that it resembles printing, except is on a much smaller scale. The process involves creating a pen-like device with a scanning probe that can place chemicals, dubbed "ink," at precise locations on a substrate. That master pen is copied over and over again so that it can become like a big stencil that can stamp features out across a wide substrate repeatedly. Since this can write features at much smaller feature sizes on the order of 10 or 20 nanometers, it could one day compete with silicon.

Hewlett-Packard is experimenting with nanoimprinting technology now in hopes of using it to create more efficient electronic components for its printers, said Williams. But there are other start-ups like Chicago-based NanoInk that are using the technology in semiconductor manufacturing. NanoInk began deploying its Dip Pen Nanolithography product last year that can be used to help repair flaws in conventional photolithography masks. These $100,000 machines can be used to fix the masks.

Williams anticipates that information technology companies will benefit from nanoimprinting because it can be used to construct molecular-scale memory chips. He also believes that it can be used to create tiny sensors that can be built into radio tags and attached to just about anything that needs to be tracked, from retail items that carry bar codes to trees that can alert forest rangers if they are burning. Those sensors will be used to detect pathogens in the air such as anthrax spores.

There are approximately 100 companies making tools for nanotechnology today, with about two thirds of them selling devices. Imago Scientific Instruments, based in Madison, Wis., makes 3-D atom-probe microscopes that can discern images of atoms down to a single nanometer. Imago sells its microscopes for about $2 million a piece to semiconductor makers who use them to inspect chips. It also hopes the microscopes will be useful in inspecting data storage or biomaterials devices.

Companies like Intel expect to be using nanotech tools as they move deeper into chip miniaturization. But Paolo Gargini, an Intel fellow and director of technology strategy at the world's biggest chip maker, said he doesn't really



expect nanotechnology to become more cost effective than conventional silicon manufacturing until about 2015. At that point, conventional lithography is expected to hit its limits with feature sizes around 10 nanometers or so. "Nanotechnology is something we're planning for and it is happening on a schedule," Gargini said.

From this brief historic view of nano-technology it's easy to see that the science was well developed by 2001 and the types of technologies available on a nano-scale for demolition were plentiful. The military industrial complex; companies such as Raytheon, Boeing, SAIC and many, many others, the military itself included, should be expected to have developed advanced technologies in the field of nano-explosive demolition by the year 2001 and the simplest, least expensive and least time consuming in terms of manpower would have been to use numerous easily disguised micro-nuclear devices the size of an apple or grapefruit.
This report asserts that theory based on advances in nano-technology between the late 1950s and 2000 and the elements discovered in the atmospheric dust by the Delta Group and Dr. Thomas Cahill, atmospheric physicist and the United States Geologic Survey and their scanning electron microscopy (SEM) analysis of 35 dust samples mapped and retrieved from Ground Zero along with other similar relevant data. Here's a short anecdotal note on Richard P. Feynman:

Feynman is especially admired by science students for his published lectures on first-year physics, with striking insights into the way a great theorist thinks about even the most elementary physics problems. Alan Harris writes:

"Perhaps my most striking memory of a Feynman lecture was not of one I attended, but of one being prepared for the class ahead of me. I was doing my weekly lab work in the freshman physics lab. At one point, as I walked out into the hall to get a drink of water, I heard a familiar voice coming from the lecture room at the other end of the hall. I peeked in to discover Feynman practicing to an empty lecture hall the lecture he was to deliver an hour or so later. It was a full dress rehearsal, with all the gestures, enthusiasm, and chalkboard notations. The excellent choreography [of his lectures] was no accident. What impressed me so deeply was that here was the world's most famous living physicist taking such care to present this material to lower-division undergraduates."
Source: Physics Today (Nov. 2005), p. 12

"*The adventure of our science of physics is a perpetual attempt to recognize that the different aspects of nature are really different aspects of the same thing*" – Richard Feynman

Feynman was known to be passionate about drumming, but he was irritated when people found this surprising in a famous scientist. In 1966 a Swedish encyclopedia publisher wrote asking for a photograph of Feynman "*beating the drum*" to give "*a human approach to a presentation of the difficult matter that theoretical physics represents.*"

This was his reply:

"Dear Sir,

The fact that I beat a drum has nothing to do with the fact that I do theoretical physics. Theoretical physics is a human endeavor, one of the higher developments of human beings, and the perpetual desire to prove that people who do it are human by showing that they do other things that a few other humans do (like playing bongo drums) is insulting to me. I am human enough to tell you to go to hell.
Yours, RPF"

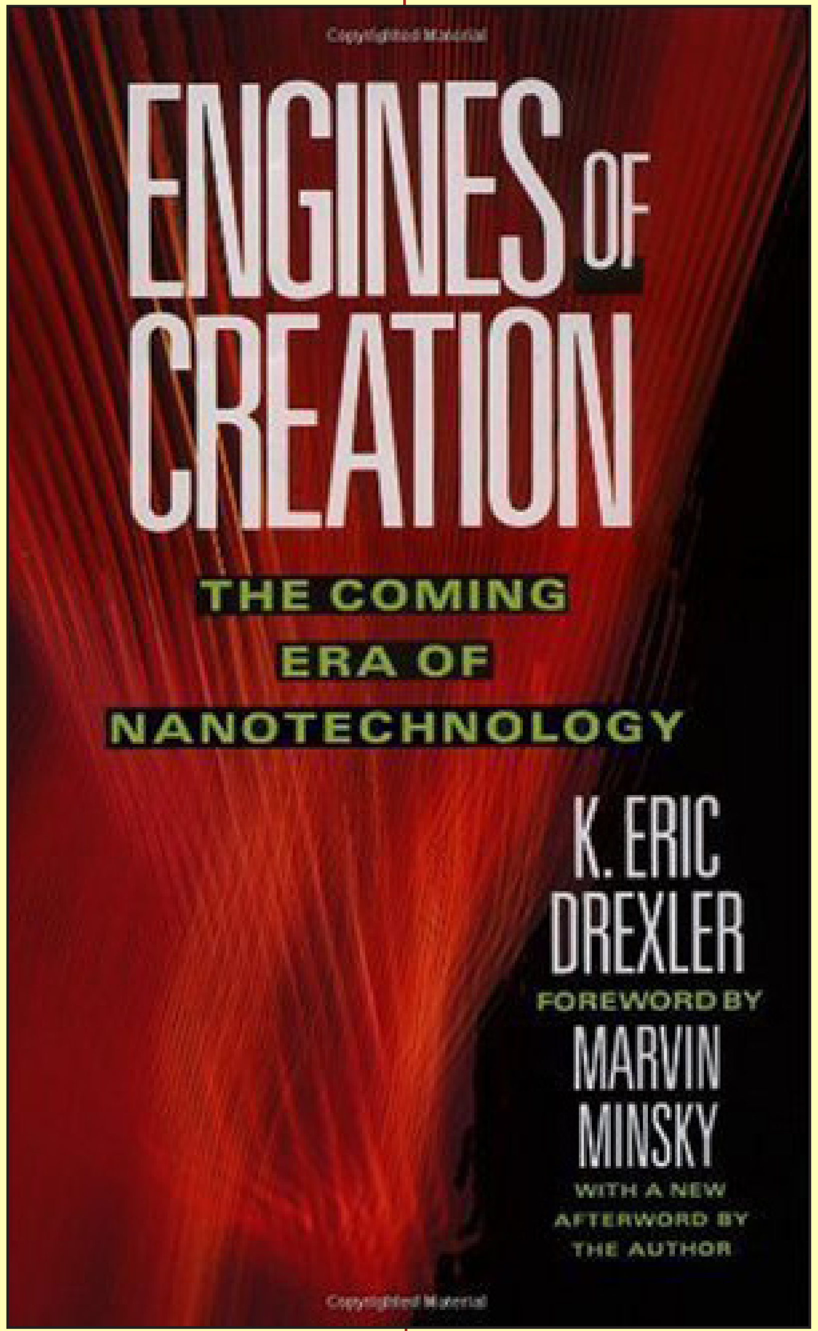
– Letter from Christopher Sykes' 'No Ordinary Genius'.

6 BOOK REVIEWS OF "ENGINES OF CREATION" A BOOK BY K. ERIC DREXLER

http://e-drexler.com/p/06/00/EOC_Cover.html

Editors Note: This book was written and published in 1986 and is reviewed for that very reason. Understanding where nano-tech started and where it's been is important to the events of 911.

Nanotechnology, or molecular technology, involves the manipulation of individual atoms and molecules. In this book Drexler considers the implications of this technology.



Nanotechnology Now Review

Published in 1987, this book is the first thorough, albeit now dated, description of Nanotechnology, the science behind it, a history to that point, predictions as to some possibilities, and some cautions. K. Eric Drexler provides the reader with an inside glimpse of the hows and whys regarding the multidisciplinary technologies that are working both together and apart to bring us the possibility of abundance, vastly greater health & longevity, and a variety of other science fiction-esque outcomes. We highly recommend it, and believe it should be one of the first books you read when you start on the road to understanding Nanotechnology, MEMS [microelectromechanical systems], Molecular-scale Manufacturing, Nanobiotechnology, Nanoelectronics, Nanofabrication, Molecular Nanoscience, Molecular Nanotechnology, Nanomedicines, Computational Nanotechnology, Biomedical Nanotechnology, Artificial Intelligence, Extropy, Transhumanism, and Singularity. If you are like me, reading it online does not cut it--so I bought the book. Somehow, holding it in my hands, and being able to lend it, makes all the difference!

From the Publisher

This brilliant work heralds the new age of nanotechnology, which will give us thorough and inexpensive control of the structure of matter. Drexler examines the enormous implications of these developments for medicine, the economy, and the environment, and makes astounding yet well-founded projections for the future.

From the Critics • A.J. Read - Choice

Drexler (research affiliate, MIT's Space Systems Laboratory) makes a plausible and easily readable case for expecting technological developments in artificial intelligence and molecular engineering (including bioengineering) that will result in tiny mechanisms controlled by microscopic powerful thinking computers--capable of assembling atoms and molecules in a few minutes into any desired macroscopic object, perhaps even living organisms. . . . Drexler also explores questions of what humanity must develop in the way of social, moral, and governmental systems to make a future of such effortless material abundance worth living in, presuming that life is not first annihilated by misuse of the new technology. His 40 pages of notes and references are regrettably rendered useless by the total lack of the usual indicators in the body of the text directing the reader to the notes. Nevertheless, this book can be recommended for college and public library collections in the relations of technology and society.

From Michael Swaine - Dr. Dobb's Electronic Review of Computer Books
Little Engines That Could

A scientist becomes a perfect superman after injecting himself with self-replicating microscopic machines that continually repair his organs. A man rents a device that sets tiny machines loose in his brain, rewiring it so that he becomes, for a brief time, a different person. A cell-repair nanotech machine -- a "nanny" -- fed with one person's DNA and set to repairing another's cells, begins turning the second person into the first. Infoviruses systematically reprogram human genes, redirecting evolution. Society is reshaped from top to bottom by nanotechnology. Experimental nanomachines escape from the lab and destroy the world.

Mere science fiction, you say? Of course. Specifically, these are the plots of several science fiction stories appearing in Nanotech, a collection of cautionary tales in the subgenre of nanotechnology-based science fiction, edited by Jack Dann and Gardner Dozios (Ace Books, 1998; ISBN 0-441-00585-3). Science fiction writers were profoundly influenced by the publication of Eric Drexler's Engines of Creation. In that book and in the more technical Nanosystems: Molecular Machinery, Manufacturing, and Computation (John Wiley & Sons, 1992; ISBN 0-47-157-518-6), Drexler defined the field of nanotechnology, mapped out its challenges, and articulated its most promising avenues of research. A number of science fiction writers staked out nanotech as their chosen science to fictionalize, and a subgenre was born.

Others besides science fiction writers were influenced by Engines of Creation. Researchers around the world have been exploring the possibilities for nanotechnology since the book's publication. Last fall, Drexler's Foresight Institute brought the leading researchers together to explore the state of the art in nanotechnology today. So far, none of the predictions of nanotech science fiction have come true. So far.

From Terence Monmaney - The New York Times Book Review

Mr. Drexler writes that nanotechnology 'will sweep the world within ten to fifty years.' That would be nice, but it is unlikely. 'Engines of Creation' is a clearly written, hopeful forecast, remarkable for an unembarrassed faith in progress through technology. Certainly computers appeared in a hurry, and, as Mr. Drexler likes to remind us, there are footprints on the moon. Those splendid achievements haven't made any utopian dreams come true, though, and it's hard to believe nanotechnology could do that, no matter how wonderful it turns out to be.

From Library Journal

Nanotechnology, or molecular technology, involves the manipulation of individual atoms and molecules, something the human body already does. In Engines of Creation, Drexler attempts to predict, justify, quantify, and caution us about this important new field in engineering. His book could have been the first and foremost discussion of this fascinating subject. But Drexler strays from the topic with annoying regularity. He devotes too little space to the possibilities of nanotechnology and too much to esoteric and opinionated discussions of philosophy, politics, information science, defense, human relations, etc. Nanotechnology will indeed become a reality, and the public needs to be informed. It is therefore unfortunate that Engines of Creation was not written more clearly or directly. Kurt O. Baumgartner, International Minerals & Chemical Corp., Terre Haute, Ind.

NANO IN THE NUCLEAR

Who hasn't marveled at the sight of a droplet gliding across a hot surface, somehow surviving well past its logical lifetime? Interestingly, MIT's Jacopo Buongiorno and Lin-Wen Hu say curbing that mundane phenomenon could lead to big benefits in terms of producing electricity.

Buongiorno is an assistant professor of nuclear engineering and Hu is associate director of the MIT nuclear reactor lab. The two want to deploy what are known as nanofluids as circulating coolants in nuclear plants. If it works, the gains could be startling. "*You can think about taking a 1,000-megawatt plant*," says Buongiorno, "*and turning it into a 1,400-megawatt plant.*"

Jacopo Buongiorno and associate Lin-Wen Hu are studying how fluids containing nanoparticles can lead to higher power outputs at nuclear plants.

Nanofluids are liquids that harbor nanoparticles. And the reason these near-infinitesimal objects may be able to boost a nuclear plant's output relates to those gliding droplets. The droplets survive, notes Buongiorno, because "*there's a vapor film that forms between the droplet and the surface. That allows the droplet to dance around for a while before it boils away*." What works for a droplet doesn't for a nuclear plant, though. One key to the efficiency of such plants is how well heat is transmitted to the coolant as it works its way up through the vertical pipes bearing the high-temperature nuclear fuel.

If the coolant simply boils, that's fine. But if a vapor film forms between the liquid and the piping wall adjoining the radioactive materials, notes Hu, "*the ability of the system to transfer heat to the coolant goes down dramatically.*" The scientists want to reduce the chance such films will form by using nanofluids. The fluids' nanoparticles may be any of a range of materials, from aluminum oxide to — yes — diamond dust. But what's striking about the approach is that it takes a truly minuscule supply of particles.

"*We get dramatic enhancements of the critical heat flux with the nanoparticles at concentrations of .001 percent*," notes Buongiorno. "*It's almost magical.*"

No one quite understands how particles at such concentrations can do what they do. In fact, Buongiorno and Hu are exploring that point. The first nuclear-plant applications of nanofluids may not be as day-to-day coolants but rather as replacements for the emergency coolants every plant must have. That in itself would save meaningful sums. The use of nanofluids as circulating coolants, meanwhile, must await further studies of issues like whether they might damage a plant's piping.

"*Preliminary results from experiments at MIT's research reactor have been promising," notes Hu, "but we need additional in-core testing to determine how these specialized nanofluid particles will react under the harsh radiation environment of a working power plant.*" Assuming those studies pan out, though, the potential's great. "*There are more than 400 nuclear plants worldwide,*" says Buongiorno, "*and in principle, most of them could be retrofitted to handle nanofluids.*"

Nanotech • Making Nuclear Weapons Much, Much Tinier

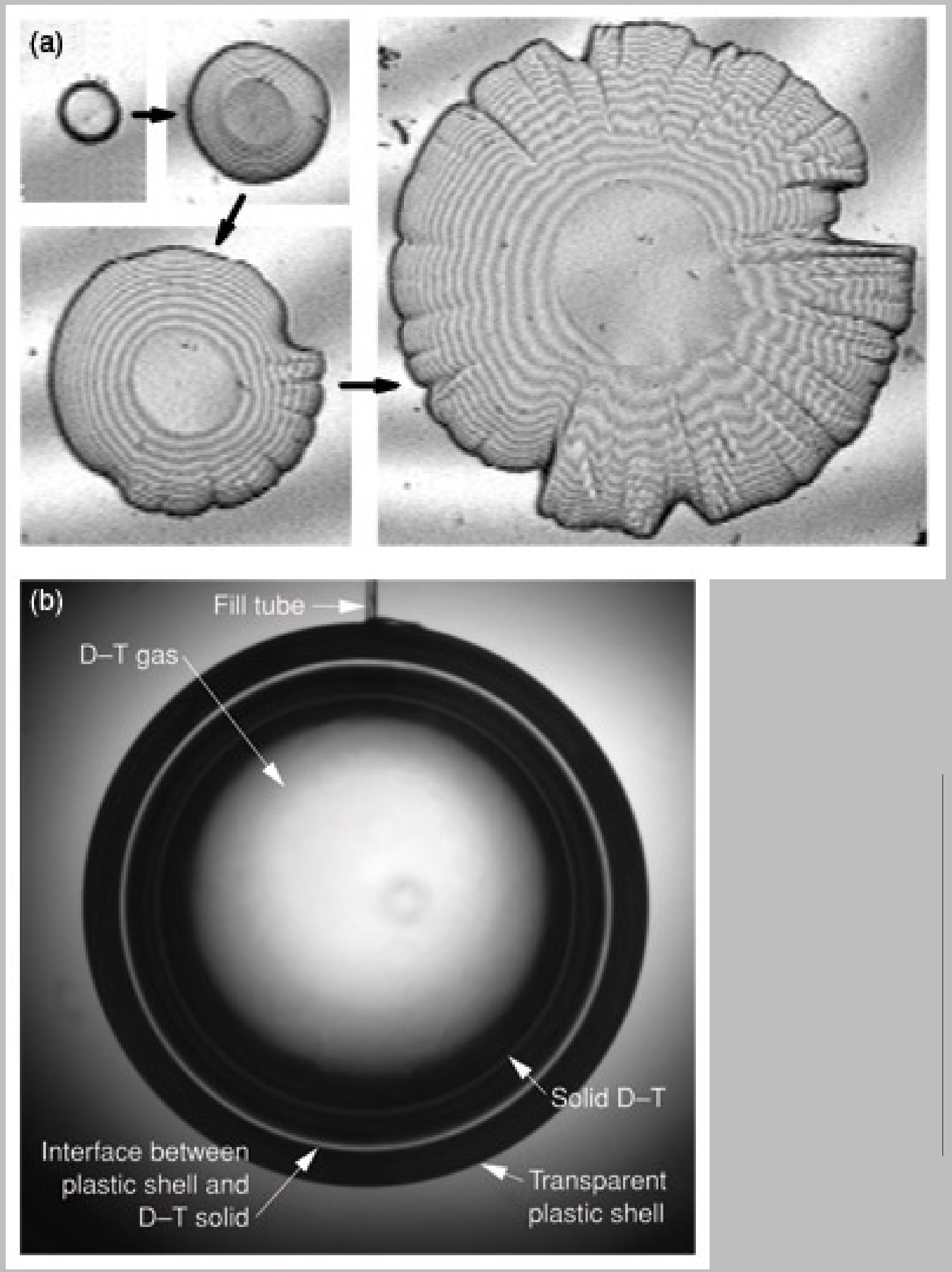
Are you ready for nano-weapons of mass destruction? Nanotechnology could be used to create "miniaturized nuclear weapons" that would have virtually no fallout, and super-efficient bioterrorism, warns Jane's Defense Quarterly. And they could be triggered with a super-laser!

A new article in the Miami Herald raises a terrifying prospect for nanotech warfare:

Jane's, the London-based research group that publishes the industry standard Jane's All the World's Aircraft, warns that nanotechnology can be used to create entirely new hazards such as miniaturized nuclear weapons that are smaller, lighter, easier to transport and hide and smuggle into unsuspecting countries. It says nano techniques designed to deliver medicines in a more-targeted way also can deliver toxic substances in a form of bioterrorism.

Nanotechnology, in which materials are machined on a molecule-by-molecule, or atom-by-atom basis, could produce super-nukes that are so tiny, they don't technically qualify as weapons of mass destruction, Jane's has warned in past articles.

In one 2003 article, Jane's warns that "*some advanced technology, such as superlaser*" could trigger a relatively small thermonuclear explosion involving a deuterium-tritium mixture, in a device weighing no more than a few kilograms. The device could go from a fraction of a ton to "*many tens of tons*" of high-explosive equivalent yield, and because they use little to no fissionable materials, they would have "*virtually no radioactive fallout.*" Self-replicating nanotech could also produce conventional weapons in such quantities that they would become WMDs.



Interferometric images of a deuterium-tritium crystal

(a) Interferometric images of a growing deuterium–tritium (D–T) crystal show a layer of the crystal that is growing more rapidly than those in the center, leading to a rough surface.

(b) Visible light illuminates a transparent plastic shell in which D–T crystals have fused together to form a perfect circle, or interface, between a solid layer of D–T and the shell's center of D–T gas. Liquid D–T is poured into the fill tube at the top, and the liquid is slowly cooled to form the solid layer.

a relatively small

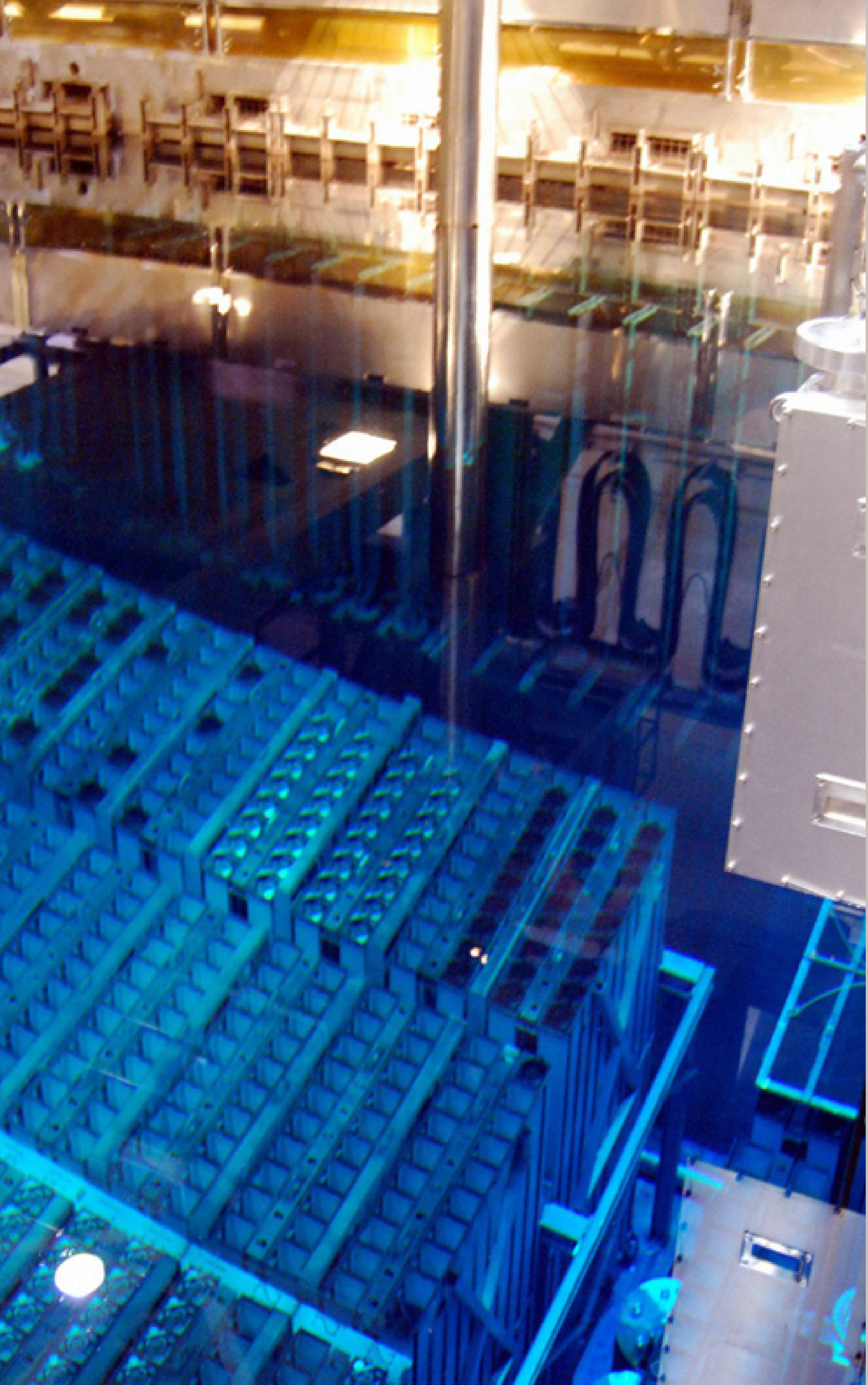
thermonuclear explosion

involving a deuterium-tritium mixture

in a device weighing no more

than a few kilograms

Are you scared yet?



Nanotech Research into Improving Cladding of Nuclear Fuel Rods

A report from the Institute for Policy Studies says that the spent nuclear fuel currently stored in pools at dozens of sites in the U.S. poses a danger and should be moved into dry storage as soon as possible.

Plutonium-uranium mixed oxide (MOX) fuel rods are placed in a storage pool at the No. 3 reactor of the Fukushima Daiichi nuclear power plant in a photo taken before the disaster (at left) in August 2010. A report from the Institute for policy studies says there are serious risks from such pools in the U.S.

The report, authored by Robert Alvarez, who served as a Senior Policy Advisor to the Secretary of Energy during the Clinton administration, says the problem is that too often the spent fuel pools are storing more fuel – and more highly radioactive fuel – than they were designed for.

Alvarez also says there have been at least 10 incidents in the last decade in which the spent fuel pool lost a significant amount of water, and there are other cases in which the systems that keep the pools functioning as they should are under strain. Much of this, he says, is simply because most of the pools in the country are at capacity already. The United States has 65,000 metric tons of spent fuel at various facilities. About 75 percent of it is stored in the pools. Spent fuel rods are, when they are first removed from a reactor, highly radioactive.

Last July, Dr. Hongbing Lu, a nanomaterials expert and researcher at the University of Texas at Dallas, received nearly $900,000 from the US Department of Energy (DoE) to begin to look at how it may be possible to improve the materials used for cladding nuclear fuel rods.

At the time of the announcement, it seemed the main benefit to come from the research would be a reduction in fuel burn rate and increasing efficiency of nuclear power plants. But now with the unfolding nuclear disaster in Japan one can't help but wonder if improving the cladding materials of the nuclear rods might have helped avoid leakage when the rods were temporarily exposed. Lu was planning to first investigate how cracks propagate in the materials and then ultimately to start looking at various materials that could avoid this kind of cracking.

"*We're working on a very general simulation methodology that can be applied to that kind of environment,"* Lu said. *"It's more than just crack growth. We need to understand how the material behaves under extreme pressure, temperature, corrosion and irradiation. With the methodology we're using, we're taking all of those factors into consideration and incorporating material behaviors into some mathematical models to describe them under very complicated conditions.*"

At the time of the article announcing the DoE research grant, Lu expected that the materials research they were conducting would not only be beneficial for the materials cladding the nuclear fuel rods but also for other parts of nuclear devices.

Nuclear Nano Materials

Next generation nuclear power plants using nano-technology will operate at higher temperatures and the materials used in their construction will experience significantly higher levels of radiation and heat than current designs (*125 million degrees and more*). It is therefore vital to thoroughly understand the effects of high radiation doses on material properties. Radiation creates defects and, over time, these defects migrate and coalesce to form voids, bubbles and dislocation loops, all of which affect the strength and performance of the materials. Radiation effects are important, not only for structural materials in fission and fusion power plants but also in nuclear fuel elements, nuclear demolition, missiles and warfare as well as in materials used for the long term storage of radioactive waste. Nanotechnology is at the forefront of all of these technical challenges.

Building 7 • September 13, 2001

NANOROBOTICS

Nanorobotics is the emerging technology field creating machines or robots whose components are at or close to the scale of a nanometer (10^{-9} meters). More specifically, nanorobotics refers to the nanotechnology engineering discipline of designing and building nanorobots, with devices ranging in size from 0.1-10 micrometers and constructed of nanoscale or molecular components. The names nanobots, nanoids, nanites, nanomachines or nanomites have also been used to describe these devices currently under research and development.

Nanomachines are largely in the research-and-development phase, but some primitive molecular machines have been tested. An example is a sensor having a switch approximately 1.5 nanometers across, capable of counting specific molecules in a chemical sample. The first useful applications of nanomachines might be in medical technology, which could be used to identify and destroy cancer cells. Another potential application is the detection of toxic chemicals, and the measurement of their concentrations, in the environment. Recently, Rice University has demonstrated a single-molecule car developed by a chemical process and including buckyballs for wheels. It is actuated by controlling the environmental temperature and by positioning a scanning tunneling microscope tip.

Another definition is a robot that allows precision interactions with nanoscale objects, or can manipulate with nanoscale resolution. Such devices are more related to Microscopy or Scanning probe microscopy, instead of the description of nanorobots as molecular machine. Following the microscopy definition even a large apparatus such as an atomic force microscope can be considered a nanorobotic instrument when configured to perform nanomanipulation. For this perspective, macroscale robots or microrobots that can move with nanoscale precision can also be considered nanorobots.

THE NANOROBOT RACE

In the same ways that technology development had the space race and nuclear arms race, a race for nanorobots is occurring. There is plenty of ground allowing nanorobots to be included among the emerging technologies. Some of the reasons are that large corporations, such as General Electric, Hewlett-Packard and Northrop Grumman have been recently working in the development and research of nanorobots; surgeons are getting involved and starting to propose ways to apply nanorobots for common medical procedures; universities and research institutes were granted funds by government agencies exceeding $2 billion towards research developing nanodevices for medicine; bankers are also strategically investing with the intent to acquire beforehand rights and royalties on future nanorobots commercialization. Some aspects of nanorobot litigation and related issues linked to monopoly have already arisen. A large number of patents has been granted recently on nanorobots, done mostly for patent agents, companies specialized solely on building a patent portfolio, and lawyers. After a long series of patents and eventually litigations, see for example the Invention of Radio or about the War of Currents, emerging fields of technology tend to become a monopoly, which normally is dominated by large corporations.

What the public knows about nano-technology is only what the public is allowed to know. Nanofactory Collaboration, founded by Robert Freitas and Ralph Merkle in 2000 and involving 23 researchers from 10 organizations and 4 countries, focuses on developing a practical research agenda specifically aimed at developing positionally-controlled diamond mechanosynthesis and a diamondoid nanofactory that would have the capability of building diamondoid medical nanorobots.

NUBOTS

Nubot is an abbreviation for "*nucleic acid robots*". Nubots are organic molecular machines at the nanoscale. DNA structure can provide means to assemble 2D and 3D nano-mechanical devices. DNA based machines can be activated using small molecules, proteins and other molecules of DNA. Biologic circuit gate based on DNA materials has been engineered as molecular machines to allow in vitro drug delivery for targeted health problems. Such material based systems would work most closely to smart biomaterial drug system delivery, while not allowing precise in vivo teleoperation of such engineered prototypes.

MOTORS AND POWER GENERATION

Some of these dozens of basic nano-block designs will contain motors. What kind of motors? Here are some options...

1. Light-driven Motors: Rice University, for example, has demonstrated that molecular machines are possible with its "nanocar." Last year, researchers at the school revealed that they had attached a motor to the molecule-size vehicle. The motor is powered by a beam of light, making it the first nanovehicle with its own engine. Roughly 20,000 of the cars could be parked side-by-side across the diameter of a human hair, the scientists said.

2. Electrostatic Motors: Electrostatic forces—static cling—can make a motor turn. As the motor shrinks, the power density increases; calculations show that a nanoscale electrostatic motor may have a power density as high as a million watts per cubic millimeter. And at such small scales, it would not need high voltage to create a useful force.

3. Temperature-change Motors: Researchers from the Spanish National Research Council, Universitat Autònoma de Barcelona, and the Catalan Institute of Nanotechnology claim to have created the first nanomotor that is moved by changes in temperature. This is believed to be the first time a nanometre-sized motor has been created that can use changes in temperature to generate and control movements.

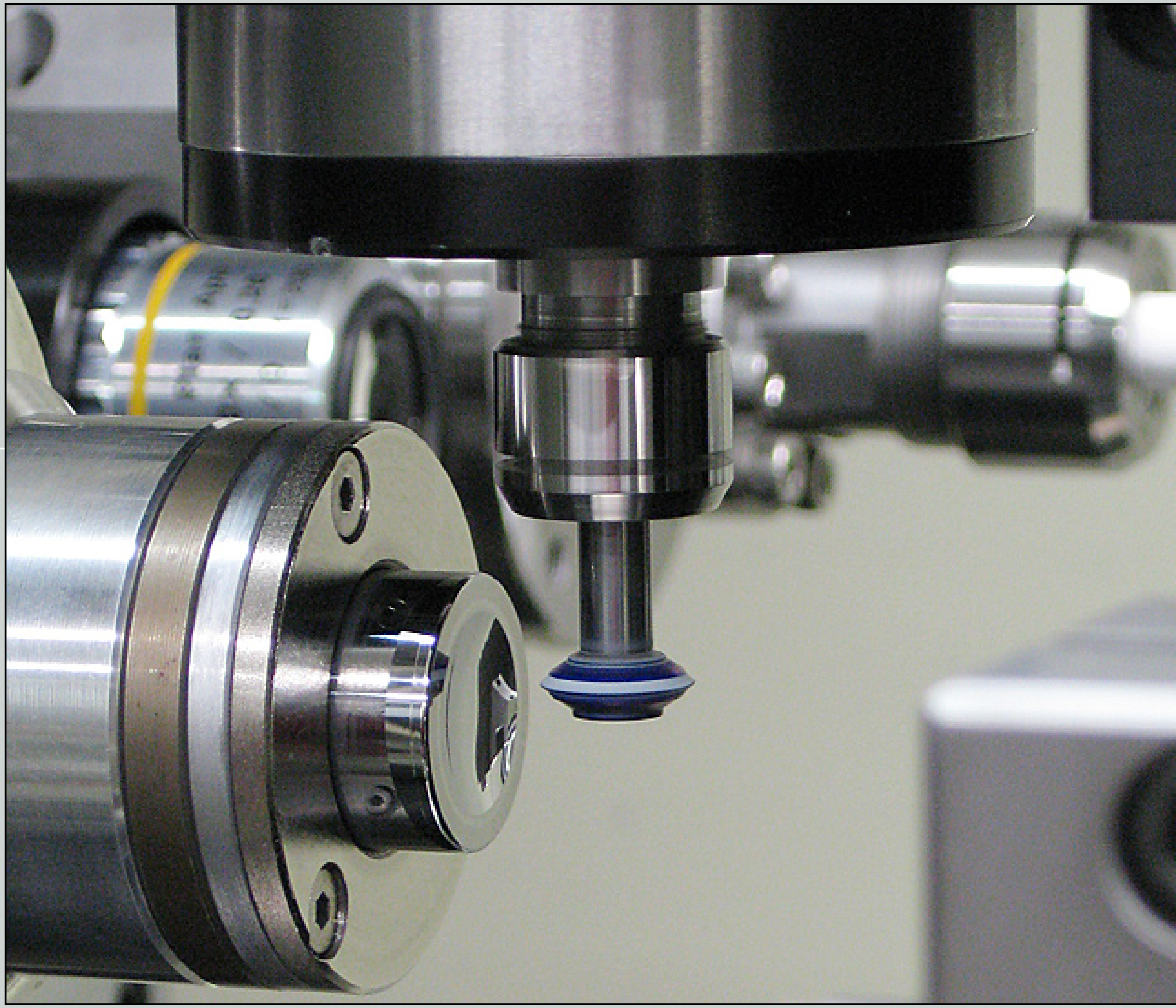
The '*nanotransporter*' consists of a carbon nanotube—a cylindrical molecule formed by carbon atoms—covered with a shorter concentric nanotube that can move back and forth or act as a rotor. A metal cargo can be added to the shorter mobile tube, which could then transport this cargo from one end to the other of the longer tube or rotate it around its axis.

Researchers are able to control these movements by applying different temperatures at the two ends of the long nanotube. The shorter mobile tube thus moves from the warmer to the colder area in a similar manner to the way in which air moves around a heater. The movements along the longer tube can be controlled with a precision of less than the diameter of an atom. This ability to control the objects at the nanometre scale can be extremely useful for future nano-electromechanical applications. Note that this new motor can control movement "*with a precision of less than the diameter of an atom*" — in other words, with atomic precision.

21ST CENTURY NANO-TECH

Moore Nanotechnology Systems, LLC (Nanotech®) is dedicated to the development of ultra-precision machining systems and their successful utilization through the formation of lifelong customer partnerships. Total customer satisfaction of our products and services has always been, and will continue to be, our highest priority as we support our customer's expansion into new markets through the design and development of new products, complimentary machine accessories, and enhancements to our existing products.

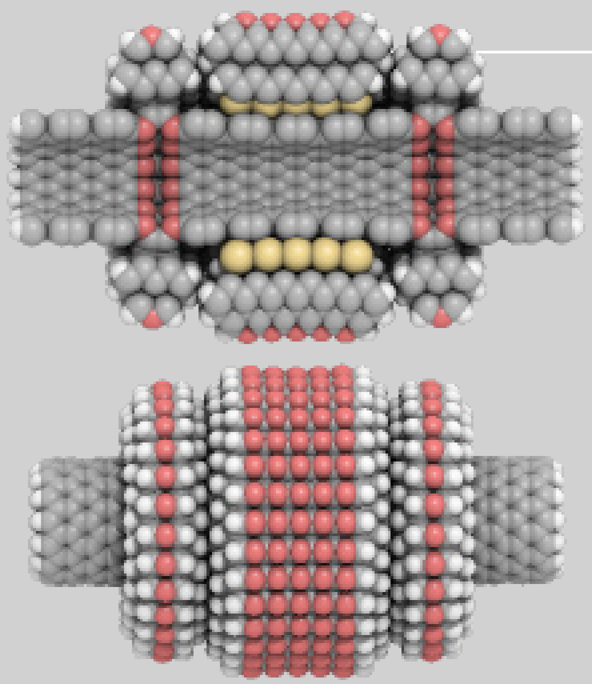
Our ultra-precision machine systems support single point diamond turning, deterministic micro-grinding, precision micro-milling, and glass press molding for the production of advanced optics including diamond turning sphere, asphere, freeform, conformal, lens array, and plano surfaces. We offer a diverse line of options and accessories to customize our machining platforms to suit our customer's specific applications, including our state-of-the-art NFTS-6000 Fast Tool Servo system and our industry leading NanoCAM® 3D Freeform programming and analysis software.



To view actual moving molecular nano-machinery we highly recommend this link, it's fascinating: http://nanoengineer-1.com/content/index.php?option=com_content&task=view&id=40&Itemid=50

To view nano-Mechanosynthesis and movement at nano-scale we highly recommend this link (*click images*): http://www.nanoengineer-1.com/nh1/index.php?option=com_content&task=view&id=37&Itemid=49

NANO-TECHNOLOGY MACHINERY



Low-friction Carbon Nanotube Bearing Assembly

Description:
The high tensile strengths and stiffness of carbon nanotubes have made them important as building materials in many current nanoscience applications. Their range of use is expected to extend to molecular manufacturing applications in nanoscale scaffolding and molecular electronics. Their cylindrical shape and highly delocalized electronic structure make them interesting possible choices for the design of molecular bearing assemblies. In the design at left, the cut-away section is a single covalent structure, around which a low-friction diamondoid bearing is kept from finding a highly stable minimum energy position.

Author:
Damian G. Allis
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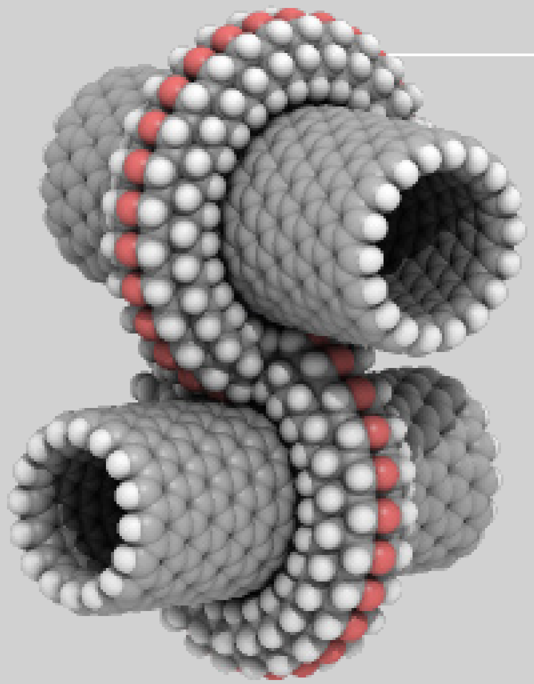

Carbon Nanotube Crimp Junction

Description:
The high tensile strengths of carbon nanotubes make them likely material candidates in future nanoscale manufacturing applications. In the absence of atomically precise manufacturing methods for fabricating continuous scaffoldings of a single nanotube, methods that lock nanotubes into place by strong electrostatic and/or steric approaches may be possible. The diamondoid crimp junction shown at left is a single covalent nanostructure that fixes two nanotubes at right angles.

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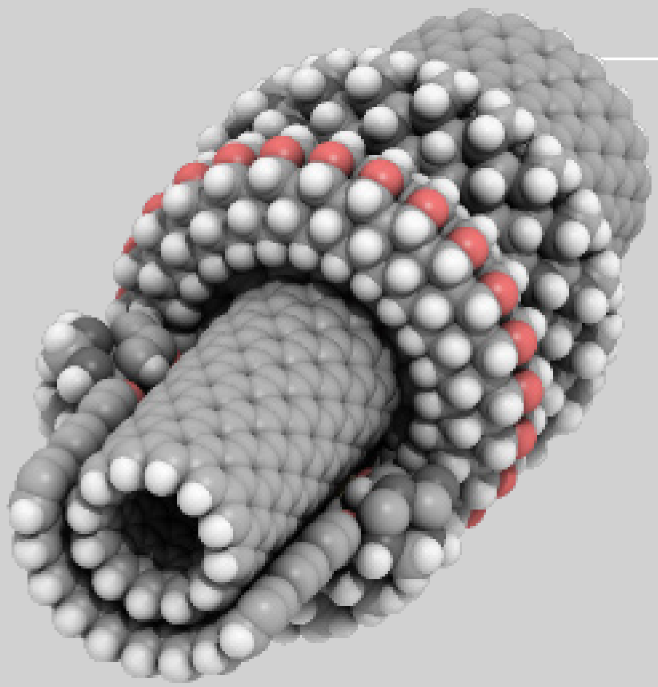

A Carbon Nanotube Molecular Bearing Assembly

Description:
The design of complex nanosystems with numerous moving parts is made complicated by the fundamental limits of chemical bonding and the possible interfaces between moving parts that can be achieved with certain nanostructures. It is possible that this spatial quantization of atomically precise building materials may also be used to drive the self-assembly of some nanosystems, greatly simplifying the assembly process. The nesting of appropriately sized carbon nanotubes, such as shown at left, can serve as a strong driving force for molecular bearing self-assembly.

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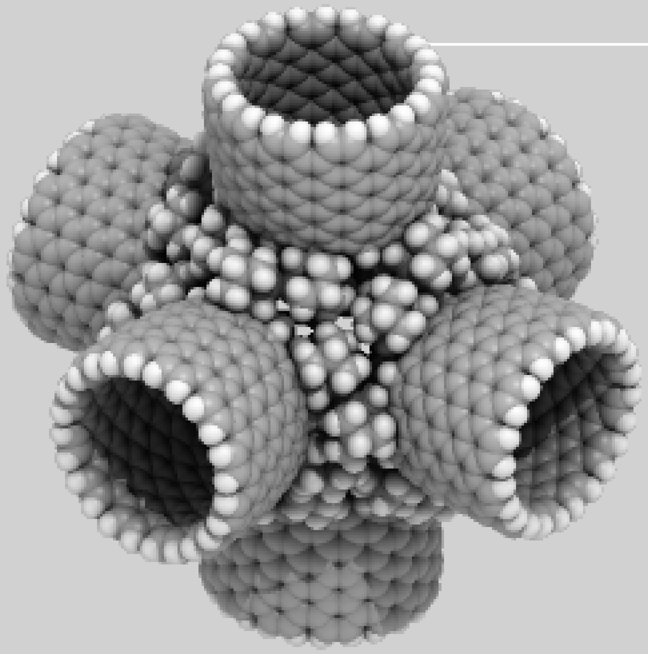

Carbon Nanotube 6-way Junction

Description:
The junction at left is generated by three pairs of carbon nanotubes fixed along (x,y,z) axes. The interfaces at the center of this junction are composed of 6 adamantane molecules covalently bound to each carbon nanutobe and functionalized with either nitrogen (N) or boron (B) atoms. These nanotubes are not covalently bound to one another, instead employing dative bonding between nearest-neighbor B-N pairs to hold the six nanotubes in place, a method that offers the possibility of complex structure formation via familiar chemical self-assembly.

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This video is amazing: http://www.nanoengineer-1.com/nh1/videos/cnt-esp.mpg

PART FOUR CONCLUSIONS

1. Nano technology is a child of the nuclear industry. They work with atoms for goodness sakes; obviously nano started in the nuclear industry and the historical record proves so. More importantly, nano technology started in the military, the military industrial complex and the war machine because that's where it was needed most.

2. Nano tech has advanced beyond our wildest dreams, quite rapidly in fact. As rapidly as the 911 First Responders dying from various rare cancers previously seen only in those exposed to radiation.

3. In the following chapter we'll see that the military desperately needed to develop cleaner nuclear weapons so that they could be used more frequently and they needed very small nuclear weapons. What's more, they needed weapons that didn't use uranium or plutonium, the only two fissionable materials banned under all international treaties for above ground testing and use. That's where the deuterium-tritium fusion fission reaction comes in. Very little uranium is produced, quite a bit of tritium is produced and the radioactivity is reduced by 97% lasting just a week or so. The tritium rapidly dissipated by either rain or water or just naturally, radiation is not easily detectable after just a week or so.

PART FIVE

Historically, nanotechnology is a child of the nuclear weapons labs, a creation of the WMD-industrial complex. The most far-reaching and fateful impacts of nano technology, therefore, may lie - and can already be seen - in the same area, nuclear technology ...

THE DEUTERIUM TRITIUM MICRO NUCLEAR BOMB

4TH GENERATION NUCLEAR WEAPONS

Tiggz 2005

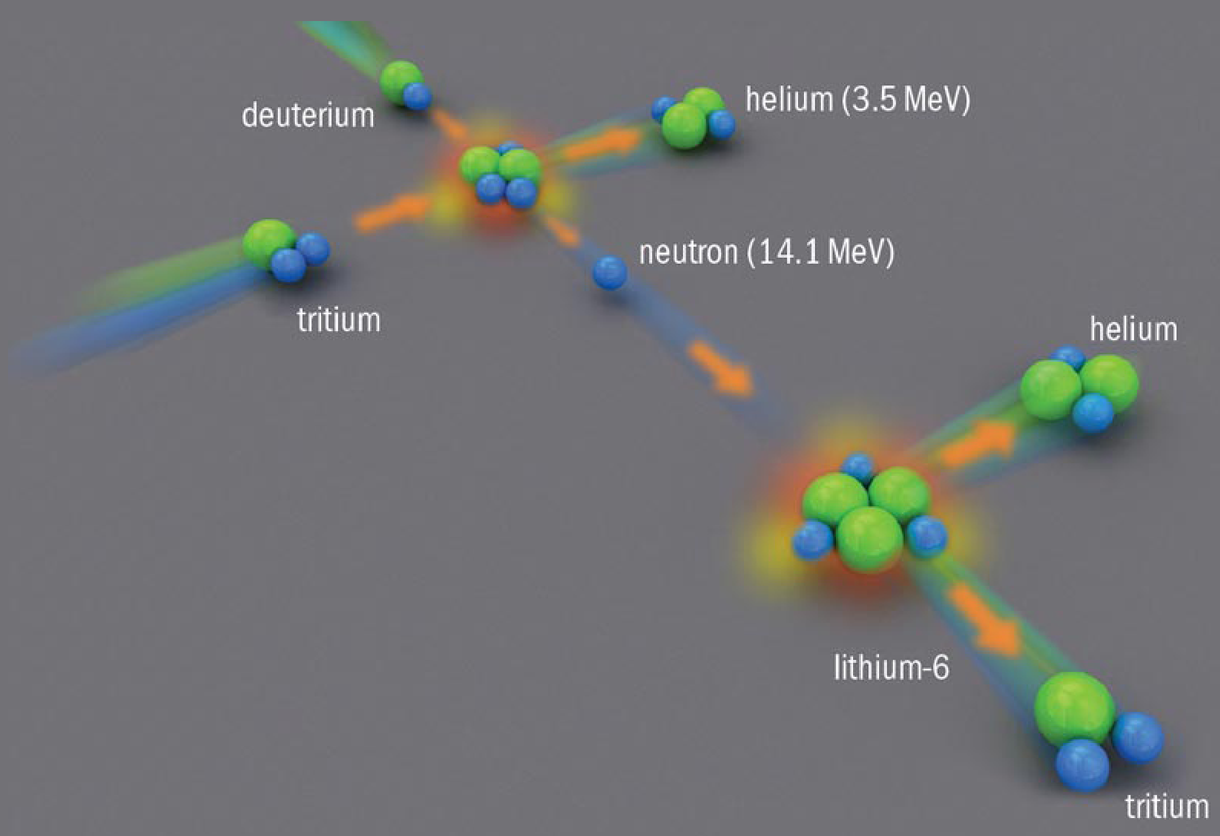
Disarmament Diplomacy

A Tritium Source at Ground Zero

Issue No. 67, October - November 2002

From the Lab to the Battlefield?
Nanotechnology and Fourth-Generation Nuclear Weapons

In Disarmament Diplomacy No. 65, Sean Howard warned of the dangers of enhanced or even new types of weapons of mass destruction (WMD) emerging from the development of 'nanotechnology', an umbrella term for a range of potentially revolutionary engineering techniques at the atomic and molecular level. Howard called for urgent preliminary consideration to be given to the benefits and practicalities of negotiating an 'Inner Space Treaty' to guard against such developments. While echoing this call, this paper draws attention to the existing potential of nanotechnology to affect dangerous and destabilizing 'refinements' to existing nuclear weapon designs. Historically, nanotechnology is a child of the nuclear weapons labs, a creation of the WMD-industrial complex. The most far-reaching and fateful impacts of nanotechnology, therefore, may lie - and can already be seen - in the same area.



The Strategic Context

Two important strategic lessons were taught by the last three wars in which the full extent of Western military superiority was displayed: Iraq, Yugoslavia, and Afghanistan. First, the amount of conventional explosive that could be delivered by precision-guided munitions like cruise missiles was ridiculous in comparison to their cost: some targets could only be destroyed by the expenditure of numerous delivery systems while a single one loaded with a more powerful warhead would have been sufficient. Second, the use of weapons producing a low level of radioactivity appears to be acceptable, both from a military point of view because such a level does not impair further military action, and from a political standpoint because most political leaders, and shapers of public opinion, did not object to the battlefield use of depleted uranium.

These lessons imply a probable military perception of the need for new conventional or nuclear warheads, and a probable political acceptance of such warheads if they do not produce large amounts of residual radioactivity. Moreover, during and after these wars, it was often suggested that some new earth-penetrating weapon was needed to destroy deeply buried command posts, or facilities related to weapons of mass destruction.

It is not, therefore, surprising to witness the emergence of a well-funded scientific effort apt to create the technological basis for making powerful new weapons - an effort that is not sold to the public opinion and political leaders as one of maintaining a high level of military superiority, but rather as one of extending human enterprise to the next frontier: the inner space of matter to be conquered by the science of nanotechnology.

The Military Impact of Nanotechnology

Nanotechnology, i.e., the science of designing microscopic structures in which the materials and their relations are machined and controlled atom-by-atom, holds the promise of numerous applications. Lying at the crossroads of engineering, physics, chemistry, and biology, nanotechnology may have considerable impact in all areas of science and technology. However, it is certain that the most significant near term applications of nanotechnology will be in the military domain. In fact, it is under the names of 'micromechanical engineering' and 'microelectromechanical systems' (MEMS) that the field of nanotechnology was born a few decades ago - in nuclear weapons laboratories.

A primary impetus for creating these systems was the need for extremely rugged and safe arming and triggering mechanisms for nuclear weapons such as atomic artillery shells. In such warheads, the nuclear explosive and its trigger undergo extreme acceleration (10,000 times greater than gravity when the munition is delivered by a heavy gun). A general design technique is then to make the trigger's crucial components as small as possible. For similar reasons of extreme safety, reliability, and resistance to external factors, the detonators and the various locking mechanisms of nuclear weapons were increasingly designed as more and more sophisticated microelectromechanical systems. Consequently, nuclear weapons laboratories such as the Sandia National Laboratory in the US are leading the world in translating the most advanced concepts of MEMS engineering into practice.

A second historical impetus for MEMS and nanotechnology, one which is also over thirty years old, is the still ongoing drive towards miniaturisation of nuclear weapons and the related quest for very-low yield nuclear explosives which could also be used as a source of nuclear energy in the form of controlled microexplosions. Such explosions (with yields in the range of a few kilograms to a few tons of high-explosive equivalent) would in principle be contained - but they could just as well be used in weapons if suitable compact triggers are developed. In this line of research, it was soon discovered that it is easier to design a micro-fusion than a micro-fission explosive (*which has the further advantage of producing much less radioactive fallout than a micro-fission device of the* *same yield*). Since that time, enormous progress has been made, and the research on these micro-fusion bombs has now become the main advanced weapons research activity of the nuclear weapons laboratories, using gigantic tools such as the US National Ignition Facility (NIF) and France's Laser Mégajoule. The tiny pellets used in these experiments, containing the thermonuclear fuel to be exploded, are certainly the most delicate and sophisticated nano-engineered devices in existence.

A third major impetus for nanotechnology is the growing demand for better materials (and parts made of them) with extremely well characterised specifications. These can be new materials such as improved insulators which will increase the storage capacity of capacitors used in detonators, nano-engineered high-explosives for advanced weaponry, etc. But they can also be conventional materials of extreme purity, or nano-engineered components of extreme precision. For instance, to meet NIF specifications, the 2-mm-diameter fuel pellets must not be more than 1 micrometer out of round; that is, the radius to the outer surface can vary by no more than 1 micrometer (***out of 1,000***) as one moves across the surface. Moreover, the walls of these pellets consist of layers whose thicknesses are measured in fractions of micrometers, and surface-smoothness in tens of nanometers; thus, these specifications can be given in units of 1,000 or 100 atoms, so that even minute defects have to be absent for the pellets to implode symmetrically when illuminated by the lasers.

The final major impetus for MEMS and nanotechnology, which has the greatest overlap with non-military needs, is their promise of new high-performance sensors, transducers, actuators, and electronic components. The development of this field of applications is expected to replicate that of the micro-electronic industry, which was also originally driven by military needs, and which provides the reference for forecasting a nano-industrial boom and a financial bonanza. There are, however, two major differences. First, electronic devices which can be manufactured in large quantities and at low cost are essentially planar, while MEMS are three-dimensional devices which may include moving parts. Second, the need for MEMS outside professional circles (***medical, scientific, police, military***) is quite limited, so that the market might not be as wide as expected. For example, the detection and identification of chemical or biological weapon threats through specificity of molecular response may lead to all sorts of medical applications, but only to few consumer goods.

Near and Long-Term Applications and Implications of Nanotechnology

Considering that nanotechnology is already an integral part of the development of modern weapons, it is important to realize that its immediate potential to improve existing weapons (***either conventional or nuclear***), and its short-term potential to create new weapons (***either conventional or nuclear***), are more than sufficient to require the immediate attention of diplomats and arms controllers.

In this perspective, the potential long-term applications of nanotechnology (***and their foreseeable social and political implications***) should neither be down-played nor overemphasized. Indeed, there are potential applications such as self-replicating nano-robots (*nanobots*) which may never prove to be feasible because of fundamental physical or technical obstacles. But this impossibility would not mean that the somewhat larger micro-robots of the type that are seriously considered in military laboratories could never become a reality.

In light of these extant and potential dangers and risks, every effort should be made not to repeat the error of the arms-control community with regard to missile defence. For over thirty years, that community acted on the premise that a ballistic missile defense system will never be built because it will never be sufficiently effective - only to be faced with a concerted attempt to construct such a system! If some treaty is contemplated in order to control or prohibit the development of nanotechnology, it should be drafted in such a way that all reasonable long-term applications are covered. Moreover, it should not be forgotten that while nanotechnology mostly emphasizes the spatial extension of matter at the scale of the nanometer (***the size of a few atoms***), the time dimension of mechanical engineering has recently reached its ultimate limit at the scale of the femtosecond (***the time taken by an electron to circle an atom***). It has thus become possible to generate bursts of energy in suitably packaged pulses in space and time that have critical applications in nanotechnology, and to focus pulses of particle or laser beams with extremely short durations on a few micrometer down to a few nanometer sized targets. The invention of the 'superlaser', which enabled such a feat and provided a factor of one million increase in the instantaneous power of tabletop lasers, is possibly the most significant recent advance in military technology. This increase is of the same magnitude as the factor of one million difference in energy density between chemical and nuclear energy.

Radioluminescent 1.8 curies (67 GBq) 6 by 0.2 inches (150 × 5.1 mm) tritium vials are simply thin, tritium-gas-filled glass vials whose inner surfaces are coated with a phosphor. The vial shown here is brand-new.

In the present paper, the long-term impact of nanotechnology will not be further discussed. The objective is to emphasise the near- to mid-term applications to existing and new types of nuclear weapons.

Nanotechnological Improvement of Existing Types of Nuclear Weapons

Nuclear weapon technology is characterized by two sharply contrasting demands. On the one hand, the nuclear package containing the fission and fusion materials is relatively simple and forgiving, i.e. rather more sophisticated than complicated. On the other hand, the many ancillary components required for arming the weapon, triggering the high-explosives, and initiating the neutron chain-reaction, are much more complicated. Moreover, the problems related to maintaining political control over the use of nuclear weapons, i.e. the operation of permissive action links (PALs), necessitated the development of protection systems that are meant to remain active all the way to the target, meaning that all these ancillary components and systems are submitted to very stringent requirements for security, safety, and reliable performance under severe conditions.

The general solution to these problems is to favour the use of hybrid combinations of mechanical and electronic systems, which have the advantage of dramatically reducing the probability of common mode failures and decreasing sensitivity to external factors. It is this search for the maximization of reliability and ruggedness which is driving the development and application of nanotechnology and MEMS engineering in nuclear weapons science.

To give an important example: modern nuclear weapons use insensitive high-explosives (IHE) which can only be detonated by means of a small charge of sensitive high-explosive that is held out of alignment from the main charge of IHE. Only once the warhead is armed does a MEMS bring the detonator into position with the main charge. Since the insensitive high-explosive in a nuclear weapon is usually broken down into many separate parts that are triggered by individual detonators, the use of MEMS-based detonators incorporating individual locking mechanisms are an important ingredient ensuring the use-control and one-point safety of such weapons.

Further improvements on existing nuclear weapons are stemming from the application of nanotechnology to materials engineering. New capacitors, new radiation-resistant integrated circuits, new composite materials capable to withstand high temperatures and accelerations, etc., will enable a further level of miniaturization and a corresponding enhancement of safety and usability of nuclear weapons. Consequently, the military utility and the possibility of forward deployment, as well as the potentiality for new missions, will be increased.

Consider the concept of a “low-yield” earth penetrating warhead. The military appeal of such a weapon derives from the inherent difficulty of destroying underground targets. Only about 15 % of the energy from a surface explosion is coupled (***transferred***) into the ground, while shock waves are quickly attenuated when travelling through the ground. Even a few megatons surface burst will not be able to destroy a buried target at a depth or distance more than 100-200 meters away from ground zero. A radical alternative, therefore, is to design a warhead which would detonate after penetrating the ground by a few tens of meters or more. Since a free-falling or rocket-driven missile will not penetrate the surface by more than about ten meters, some kind of active penetration mechanism is required. This implies that the nuclear package and its ancillary components will have to survive extreme conditions of stress until the warhead is detonated.

Fourth-Generation Nuclear Weapons

First and second-generation nuclear weapons are atomic and hydrogen bombs developed during the 1940s and 1950s, while third-generation weapons comprise a number of concepts developed between the 1960s and 1980s, e.g. the neutron bomb, which never found a permanent place in the military arsenals. Fourth-generation nuclear weapons are new types of nuclear explosives that can be developed in full compliance with the Comprehensive Test Ban Treaty (CTBT) using inertial confinement fusion (ICF) facilities such as the NIF in the US, and other advanced technologies which are under active development in all the major nuclear-weapon states - and in major industrial powers such as Germany and Japan.

In a nutshell, the defining technical characteristic of fourth-generation nuclear weapons is the triggering - by some advanced technology such as a super-laser, magnetic compression, antimatter, etc. - of a relatively small thermonuclear explosion in which a deuterium-tritium mixture is burnt in a device whose weight and size are not much larger than a few kilograms and liters. Since the yield of these warheads could go from a fraction of a ton to many tens of tons of high-explosive equivalent, their delivery by precision-guided munitions or other means will dramatically increase the fire-power of those who possess them - without crossing the threshold of using kiloton-to-megaton nuclear weapons, and therefore without breaking the taboo against the first-use of weapons of mass destruction. Moreover, since these new weapons will use no (***or very little***) fissionable materials, they will produce virtually no radioactive fallout. Their proponents will define them as "*clean*" nuclear weapons - and possibly draw a parallel between their battlefield use and the consequences of the expenditure of depleted uranium ammunition.

In practice, since the controlled release of thermonuclear energy in the form of laboratory scale explosions (*i.e., equivalent to a few kilograms of high-explosives*) at ICF facilities like NIF is likely to succeed in the next 10 to 15 years (*remember that the military is always 10-15 years or more ahead of public domain material and this essay was written in 2002*), the main arms control question is how to prevent this know-how being used to manufacture fourth-generation nuclear weapons. As we have already seen, nanotechnology and micromechanical engineering are integral parts of ICF pellet construction. But this is also the case with ICF drivers and diagnostic devices, and even more so with all the hardware that will have to be miniaturized and '*ruggedized*' to the extreme in order to produce a compact, robust, and cost-effective weapon.

A thorough discussion of the potential of nanotechnology and micro-electromechanical engineering in relation to the emergence of fourth-generation nuclear weapons is therefore of the utmost importance. It is likely that this discussion will be difficult, not just because of secrecy and other restrictions, but mainly because the military usefulness and usability of these weapons is likely to remain very high as long as precision-guided delivery systems dominate the battlefield. It is therefore important to realize that the tech-

nological hurdles that have to be overcome in order for laboratory scale thermonuclear explosions to be turned into weapons may be the only remaining significant barrier against the introduction and proliferation of fourth-generation nuclear weapons. For this reason alone - and there are many others, beyond the scope of this paper - very serious consideration should be given to the possibility of promoting an '*Inner Space Treaty*' to prohibit the military development and application of nano-technological devices and techniques. What do you think?

DEUTERIUM
TRITIUM
MICRO
NUCLEAR
BOMBS

DEUTERIUM
TRITIUM
MICRO
NUCLEAR
BOMBS

Notes and References

1. Sean Howard, 'Nanotechnology and Mass Destruction: the Need for an Inner Space Treaty', Disarmament Diplomacy No. 65 (July/August 2002), pp. 3-16.

2. The decades-long "change from the importance of the big bang to the importance of accuracy" was emphasised by Edward Teller in a paper written shortly after the 1991 Gulf War: "Shall one combine the newly acquired accuracy with smaller nuclear weapons (perhaps even of yields of a few tons) to be used against modern weapons such as tanks and submarines?" Edward Teller, American Journal of Physics, Vol.59, October 1991, p.873.

3. Depleted uranium (DU) munitions were primarily designed to stop a massive tank attack by the nuclear-armed Warsaw Pact Organisation. Their first use during the 1991 Gulf War broke a 46-year long taboo against the intentional use or induction of radioactivity in combat.

4. Most literature related to earth-penetrating weapons refers to devices with a yield in the low kiloton range. However, some experts have argued that much less powerful devices would suffice: "A small-yield nuclear weapon (15 tons or less) would be militarily useful: it could destroy deeply buried targets that otherwise could be readily reparable, and it would do so without placing US forces at greater risk. It would also be politically useful, serving notice to the proliferant that the United States will engage it and, if necessary, escalate the conflict." Kathleen C. Bailey, 'Proliferation: Implications for US Deterrence', in Kathleen C. Bailey, ed., Weapons of Mass Destruction: Costs Versus Benefits, Manohar, New Delhi, 1994, pp. 141-142.

5. The smaller an electro-mechanical system, the higher its resistance to acceleration. This explains why it is possible to design a shock-proof wrist-watch, while a wall-clock falling on the ground is certain to be damaged.

6. Pictures of the 50-micrometer gears of Sandia's intricate safety lock for nuclear missiles were published in Science, Vol.282, October 16, 1998, pp. 402-405.

7. Richard E. Smalley, 'Of chemistry, love and nanobots', Scientific American, Vol.285, September 2001, pp. 68-69.

8. Keith W. Brendley and Randall Steeb, 'Military applications of microelectromechanical systems', Report MR-175-OSD/AF/A, RAND Corporation, 1993, 57 pp. Johndale C. Solem, 'On the mobility of military microrobots', Report LA-12133, Los Alamos National Laboratory, July 1991, 17 pp.

9. Using the language of Endnote No. 7, one can say that photons (i.e., particles of light) are, contrary to atoms, neither "fat" nor "sticky": they can be concentrated in unlimited numbers so that a very localised and brief light pulse can contain huge amounts of energy - so large that a table-top superlaser can initiate nuclear reactions such as fission or fusion.

10. As routinely defined by the US Department of Defense: "A nuclear weapon is one-point safe if, when the high explosive (HE) is initiated and detonated at any single point, the probability of producing a nuclear yield exceeding four pounds of trinitrotoluene (TNT) equivalent is less than one in a million." See, for example, http://www.dtic.mil/whs/directives/corres/pdf/3150m_1296/p31502m.pdf.

11. André Gsponer and Jean-Pierre Hurni, The Physical Principles of Thermonuclear Explosives, Inertial Confinement Fusion, and the Quest for Fourth Generation Nuclear Weapons, INESAP Technical Report No.1, Presented at the 1997 INESAP Conference, Shanghai, China, 8-10 September 1997, Seventh edition, September 2000, ISBN: 3-9333071-02-X, 195 pp.

12. André Gsponer, Jean-Pierre Hurni, and Bruno Vitale, 'A comparison of delayed radiobiological effects of depleted-uranium munitions versus fourth-generation nuclear weapons', Report ISRI-02-07, due to appear in the Proceedings of the 4th Int. Conf. of the Yugoslav Nuclear Society, Belgrade, Sep.30 - Oct.4, 2002, 14 pp. Available at http://arXiv.org/abs/physics/0210071.

DISARMAMENT DIPLOMACY

A TRITIUM SOURCE AT GROUND ZERO

Issue No. 65, July - August 2002

Nanotechnology and Mass Destruction: The Need for an Inner Space Treaty

"I think it is no exaggeration to say we are on the cusp of the further perfection of extreme evil, an evil whose possibility spreads well beyond that which weapons of mass destruction bequeathed to the nation-states, on to a surprising and terrible empowerment of extreme individuals."

~ Bill Joy, co-founder of Sun Microsystems, April 2000

Introduction

This article assesses concerns about the potential development of new weapons and risks of mass destruction made possible by nanotechnology - the rapidly evolving field of atomic and molecular engineering. It will argue that such concerns are valid and will need to be addressed by the international arms control and non-proliferation regime. The paper concludes with an appeal for such an engagement to begin sooner rather than later. Weapons of mass destruction (WMD) are already banned from outer space under the terms of the 1967 Outer Space Treaty. Before long, there may be need for an 'inner space' treaty to protect the planet from devastation caused - accidentally, or by terrorists, or in open conflict - by artificial atomic and molecular structures capable of destroying environments and life forms from within.

The Nanotechnology Revolution

Nanotechnology is defined in the Oxford English Dictionary as "the branch of technology that deals with dimensions and tolerances of less than 100 nanometres, esp. the manipulation of individual atoms and molecules." A nanometre is one billionth (*one-thousand millionth*) of a metre. Although the potential of atomic engineering on the scale of 1-100 nanometres was foreseen for decades, most famously in a 1959 lecture by the US physicist Richard Feynman, serious research was only made possible in the 1980s, primarily through the ability of a new microscope - the scanning tunnelling microscope (STM) - to 'click' and 'drag' on individual atoms. Numerous universities in North America, Europe and Asia quickly established teams to investigate the possibilities of the new research.

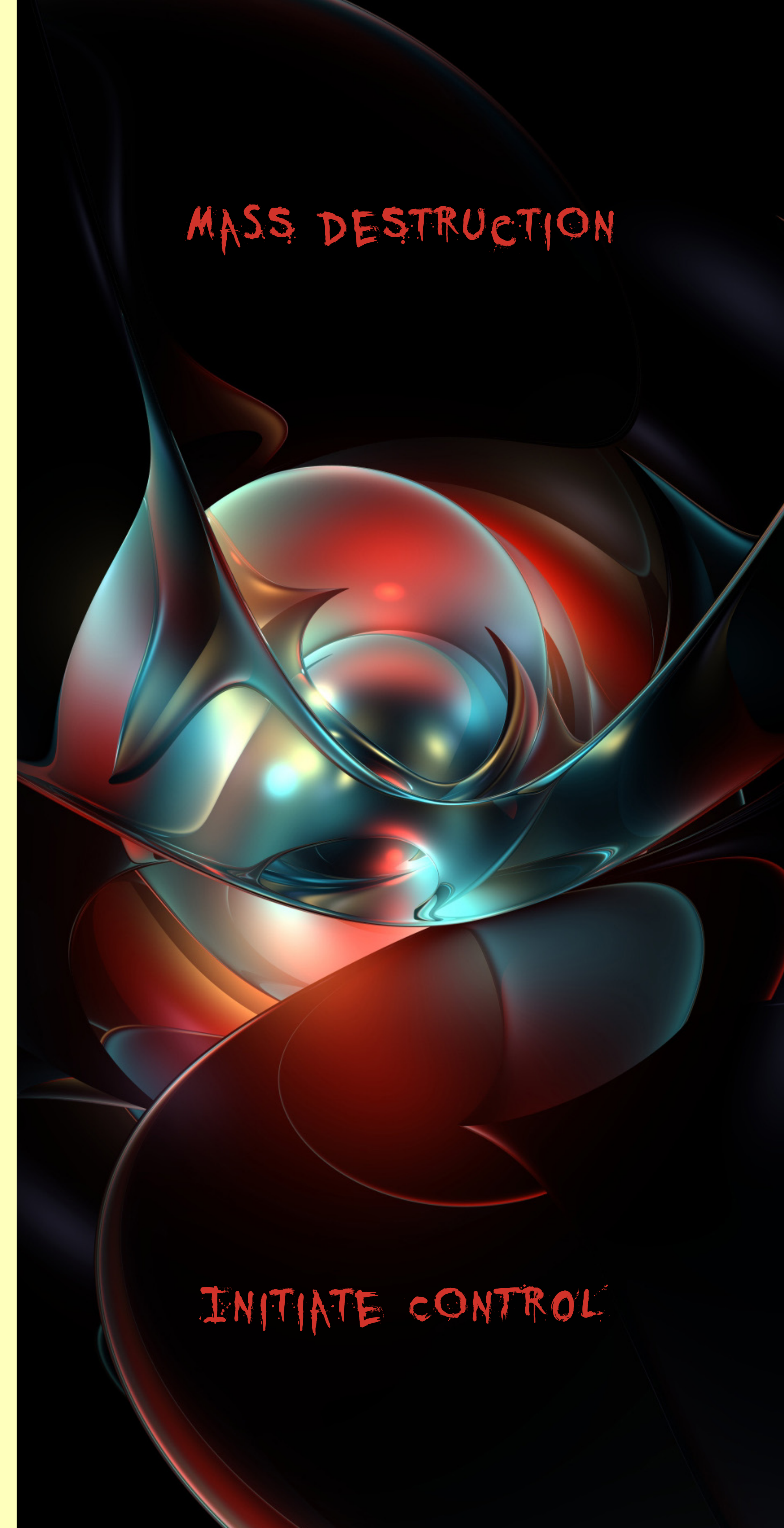
By January 2000, the US government had become sufficiently impressed with the early results to launch a National Nanotechnology Initiative (NNI), with initial funding of $497 million. While other governments are also investing in a range of nanotechnology research, the US effort is by far the most substantial - and hyped. Launching the programme, President Bill Clinton enthused: "*Imagine the possibilities: materials with ten times the strength of steel and only a small fraction of the weight; shrinking all the information housed at the Library of Congress into a device the size of a sugar cube; detecting cancerous tumors when they are only a few cells in size. Some of our research goals may take 20 or more years to achieve, but that is precisely why there is an important role for the federal government.*"

A White House Fact Sheet - entitled 'National Nanotechnology Initiative: Leading to the Next Industrial Revolution' - virtually salivated over the prospect of an atomically re-designed world:

"*The emerging fields of nanoscience and nanoengineering - the ability to manipulate and move matter - are leading to unprecedented understanding and control over the fundamental building blocks of all physical things. These developments are likely to change the way almost everything - from vaccines to computers to automobile tires to objects not yet imagined - is designed and made. ... Nanotechnology is the builder's new frontier and its potential impact is compelling: this Initiative establishes Grand Challenges to fund interdisciplinary research and education teams... that work for major, long-term objectives.*"

The chain reactions involved in thermonuclear explosions are precise and controlled, as much or more than the dosages in chemotherapy treatment

The Bush administration's first NNI budget request, for FY 2002, was for $518.9 million, increased by Congress to $604.4 million. The request for the coming fiscal year is $679 million. The range of US government partners involved reflects the technology's potential breadth of application. The second largest recipient is the Department



of Defense, with $180 million of funding dedicated to elaborating a "*conceptual template for achieving new levels of warfighting effectiveness*" reflecting "the increasingly critical nature of technological advances". None of the funding is currently earmarked specifically for developing new weapons. Studies are, however, already underway (*e.g. the research on new types of armour, considered below*) and likely to be undertaken to assess the kind of nanotechnological systems which US forces may confront, or equip themselves with, in the future. Such weapons, at least in principle, could include WMD, either in terms of entirely new means of mass destruction, or nanotechnological enhancements to existing WMD.

The incentive for an adversary to pursue the military application of atomic engineering - either on a battlefield or on a massively destructive scale - may, ironically, be increased by the evident enthusiasm of the US military for the new possibilities. As with other advanced technologies, the defensive and offensive utility of nanotechnology is hard to distinguish; from an adversary's point of view, it may even be dangerous to try.

Here, for instance, is a recent news story on 'nanoarmour' for US troops:

"The Massachusetts Institute of Technology plans to create military uniforms that can block out biological weapons and even heal their wearers as part of a five-year contract to develop nanotechnology applications for soldiers, the US Army announced... MIT won the $50 million contract to create an Institute for Soldier Nanotechnologies, or ISN. The ISN will be staffed by around 150 people, including 35 MIT professors... The unique lightweight materials that can be composed using nanotechnology will possess revolutionary qualities that MIT says will help it make a molecular 'exoskeleton' for soldiers. The ISN plans to research ideas for a soft - and almost invisible - clothing that can solidify into a medical cast when a soldier is injured or a '*forearm karate glove*' for combat, MIT said. Researchers also hope to develop a kind of molecular chain mail that can deflect bullets. In addition to protecting soldiers, these radically different materials will have uses in offensive tactics, at least psychologically.

'*Imagine the psychological impact upon a foe when encountering squads of seemingly invincible warriors protected by armour and endowed with superhuman capabilities, such as the ability to leap over 20-foot walls,' ISN director Ned Thomas said in a release*."

Imagine, one might add, the psychological impact on people around the world, first of realising that such a dramatic extension of militarisation into the nanosphere is beginning, then of wondering where such a process might end. Why stop at armour, short of new weapons - and, if it does lead to new weapons, what on earth will they be?

Fact and Fiction

Nanotechnology has become firmly established as a subject of popular interest, largely through visions of a 'return to Eden', and even an escape from mortality, offered in countless science fiction novels, films and television series, and a number of best-selling science books, prominent among them Engines of Creation by K. Eric Drexler and The Age of Spiritual Machines by Ray Kurzweil. Such works are generally derided by professional nanotechnologists, keen to caution against inflated expectations and thus possible disillusionment on the part of governments, funders and industry. Even the vision of nanotechnology purveyed by such professionals, however, is replete with expressions of confidence in its long-term capacity to transform the modern world - for the better, of course.

In September 2001 - a month synonymous with the destructive misuse of modern technology - Scientific American published a special issue on progress and prospects in the new '*science of the small*'. The issue, featuring articles from prominent nanotechnology advocates and practitioners, differing only in the intensity of their enthusiasm, outlines developments in four main areas of research: computer circuitry, new construction 'supermaterials', medical diagnostic and therapeutic applications, and 'nanorobotics'.

All these areas overlap, just as nanotechnology itself merges with two other 'frontier' disciplines, genetic engineering and robotics. More grandly, nanotechnology is viewed as a potentially significant step toward the 'unification' - at least in terms of a central research and development agenda - of physics, chemistry and biology. As the introduction to the special issue of Scientific American, entitled 'Megabucks for Nanotech', noted: "*Because the development of tools and techniques for characterizing and building nanostructures may have far-reaching applicability across all sciences, nanotechnology could serve as a rallying point for physicists, chemists and biologists.*"

But does this allure mean scientists are more or less likely to be wary of the potential for harm their work may entail? What 'far-reaching applicability' could '*nanostructures*' have for repressive governments, high-tech militaries, or terrorist organizations?

The dark side of nanoscale engineering has long been acknowledged outside the laboratory, both in works of science fiction and by prominent evangelists for the new faith, some of whom have suggested safeguards and protections. The extent or even existence of the threat, however, has been largely ignored or discounted in the official decisions and statements of governments, funders, industry and academy. This in turn adds to the difficulty of seeking to persuade the overstretched and under-resourced arms control diplomatic community to begin to consider its possible interest in the subject.

In the wake of September 11, however, a serious reappraisal of official attitudes toward nanotechnology is urgently required. The assumption, perhaps held most deeply in the US, is that nanotechnology can and should be enlisted in the campaign against terrorism, and that the risk of misuse is far outweighed by the likely gains. But to what extent is this more than an assumption?

Nanotechnology and Mass Destruction: an Overview of the Current Debate

Processes of self-replication, self-repair and self-assembly are an important goal of mainstream nanotechnological research. Either accidentally or by design, precisely such processes could act to rapidly and drastically alter environments, structures and living beings from within. In extremis, such alteration could develop into a ‘doomsday scenario’, the nanotechnological equivalent of a nuclear chain-reaction - an uncontrollable, exponential, self-replicating proliferation of ‘nanodevices’ chewing up the atmosphere, poisoning the oceans, etc. While accidental mass-destruction, even global destruction, is generally regarded as unlikely -equivalent to fears that a nuclear explosion could ignite the atmosphere, a prospect seriously investigated during the Manhattan Project - a deliberately malicious programming of nanosystems, with devastating results, seems hard to rule out. As Ray Kurzweil points out, if the potential for atomic self-replication is a pipe-dream, so is nanotechnology, but if the potential is real, so is the risk:

“*Without self-replication, nanotechnology is neither practical nor economically feasible. And therein lies the rub. What happens if a little software problem (inadvertent or otherwise) fails to halt the self-replication? We may have more nanobots than we want. They could eat up everything in sight. ... I believe that it will be possible to engineer self-replicating nanobots in such a way that an inadvertent, undesired population explosion would be unlikely. ... But the bigger danger is the intentional hostile use of nanotechnology. Once the basic technology is available, it would not be difficult to adapt it as an instrument of war or terrorism. ... Nuclear weapons, for all their destructive potential, are at least relatively local in their effects. The self-replicating nature of nanotechnology makes it a far greater danger*.”

Assuming replication will prove feasible, K. Eric Drexler also assumes the worst is possible: “*Replicators can be more potent than nuclear weapons: to devastate Earth with bombs would require masses of exotic hardware and rare isotopes, but to destroy life with replicators would require only a single speck made of ordinary elements. Replicators give nuclear war some company as a potential cause of extinction, giving a broader context to extinction as a moral concern*.”

There are, of course, multiple levels of concern below that of a final apocalypse. Use and abuse are, unavoidably, the twins born of controlled replication. Nanosystems proliferating in a precisely controlled and pre-programmed manner to destroy cancerous cells, or deliver medicines, or repair contaminated environments, can also be ‘set’ to destroy, poison and pollute. The chain reactions involved in thermonuclear explosions are precise and controlled, as much or more than the dosages in chemotherapy treatment. In the science of atomic engineering, the very technologies deployed to allay concerns of apocalyptic malfunction loom as the likely source of functional mass destruction.

Notwithstanding their vividly expressed concerns, both Kurzweil and Drexler portray the risk of mass- or global-destruction as a containable, preventable problem - provided nanotechnology is pursued as vigorously as possible in order to understand the real risks. In April 2000, however, an article in Wired magazine by Bill Joy, a leading computer scientist and co-founder of Sun Microsystems, painted a far bleaker picture:

“*Accustomed to living with almost routine scientific breakthroughs, we have yet to come to terms with the fact that the most compelling 21st-century technologies - robotics, genetic engineering, and nanotechnology - pose a different threat than the technologies that have come before. ... What was different in the 20th Century? Certainly, the technologies underlying the weapons of mass destruction - nuclear, biological, and chemical - were powerful, and the weapons an enormous threat. But building nuclear weapons required, at least for a time, access to both rare...raw materials and highly protected information; biological and chemical weapons programs also tended to require large-scale activities. The 21st century technologies...are so powerful that they can spawn whole new classes of accidents and abuses. Most dangerously, for the first time, these accidents and abuses are widely within the reach of individuals or small groups. ... Thus we have the possibility not just of weapons of mass destruction but of knowledge-enabled mass destruction (KMD), this destructiveness hugely amplified by the power of self-replication.*”

Joy identifies and addresses two key issues: if the danger is so great, 1) why hasn’t the warning been adequately sounded before now, and 2) what can be done to avoid the abyss? His answer to the first question is shocking and, given his own commercial success, confessional:

“*In truth, we have had in hand for years clear warnings of the dangers inherent in widespread knowledge of GNR [genetics, nanotechnology and robotics] technologies - of the possibility of knowledge alone enabling mass destruction. But these warnings haven’t been widely publicized; the public discussions have been clearly inadequate. There is no profit in publicizing the dangers... In this age of triumphant commercialism, technology... is delivering a series of almost magical inventions that are the most phenomenally lucrative ever seen. We are aggressively pursuing the promises of these new technologies within the now-unchallenged system of global capitalism and its manifold financial incentives and competitive pressures.*”

In seeking ways back from the brink, Joy’s starting point is the folly of distinguishing between military and non-military - or, more broadly, ‘good’ and ‘bad’ - nanotechnology. There is, of course, a distinction be-

A second historical impetus for MEMS and nanotechnology, one which is also over thirty years old, is the still ongoing drive towards miniaturisation of nuclear weapons and the related quest for very-low yield nuclear explosives which could also be used as a source of nuclear energy in the form of controlled micro-explosions.

tween malicious and benign intent, but the difference does not affect the inherently dangerous and/or uncontrollable nature of atomic fabrication and engineering. In view of the vast promise, both financial and scientific, involved, the tendency is to seek a technological fix, a nanotechnological equivalent to a missile defence system, to ward off any demons the same technology may conjure up. In dismissing this option, Joy draws the only remaining conclusion available:

"*In Engines of Creation, Eric Drexler proposed that we build an active nanotechnological shield - a form of immune system for the biosphere - to defend against dangerous replicators of all kinds that might escape from laboratories or otherwise be maliciously created. But the shield he proposed would itself be extremely dangerous - nothing could prevent it from developing autoimmune problems and attacking the biosphere itself. Similar difficulties apply to the construction of shields against robotics and genetic engineering. These technologies are too powerful to be shielded against in the time frame of interest; even if it were possible to implement defensive shields, the side effects of their development would be at least as dangerous as the technologies we are trying to protect against. These possibilities are all thus either undesirable or unachievable or both. The only realistic alternative I see is relinquishment: to limit development of the technologies that are too dangerous, by limiting our pursuit of certain kinds of knowledge*."

As he doubtless expected, Joy's article was widely portrayed by nanotechnology enthusiasts and practitioners as Luddite exaggeration bordering on unmanly hysteria. Gary Stix, special projects editor at Scientific American, noted scornfully that "*the danger comes when intelligent people*" take "*predictions*" of nanotechnological catastrophe "*at face value*". A "*morose Bill Joy*", Stix wrote, had "*worried... about the implications of nanorobots that could multiply uncontrollably. A spreading mass of self-replicating robots - what Drexler has labelled 'gray goo' - could pose enough of a threat to society, he mused, that we should consider stopping development of nanotechnology. But that suggestion diverts attention from the real nano goo: chemical and biological weapons.*" This parodies Joy's article, however, which considers a range of negative consequences potentially flowing from the basic fact of the nanotechnology revolution, namely that the "*replicating and evolving processes that have been confined to the natural world are about to become realms of human endeavour*". That we may not be eaten by 'gray goo' does not mean we should ignore other dire prospects. As for the 'real nano goo', Joy sees in nanotechnology the potential to dramatically enhance the mass-destructive capacity of chemical and, particularly, biological weapons, in a manner akin perhaps to the qualitative leap from atomic to thermonuclear weapons. It is precisely in the CBW area that nanotechnology is likely to pose its first major arms control challenge.

The analogy with the development of thermonuclear weapons is also instructive in the context of the possible abandonment of a field of scientific work - however uncharted and challenging the territory - on moral grounds, or out of fear of the total destruction which may follow. In 1949, the scientific General Advisory Committee (GAC) of the US Atomic Energy Commission (AEC) drew up a report on the possible development of hydrogen bombs by the United States military. The general report, adopted by eight physicists including the scientific director of the Manhattan Project, Robert Oppenheimer, stumbled on the verge of recommending that the attempt not be made: "*It is clear that the use of this weapon would bring about the destruction*

The primary impetus for creating these nano systems was the need for extremely rugged and safe arming and triggering mechanisms for nuclear weapons such as atomic artillery shells *of innumerable human lives... Its use...carries much further than the atomic bomb itself the policy of exterminating civilian populations. ... We all hope that by one means or another, the development of these weapons can be avoided.*" A supporting document, however, submitted by I.I. Rabi and Enrico Fermi, took the final step. The destructive capacity of the hydrogen bomb, they argued, "*makes its very existence and the knowledge of its construction a danger to humanity as a whole. It is necessarily an evil thing considered in any light.*"

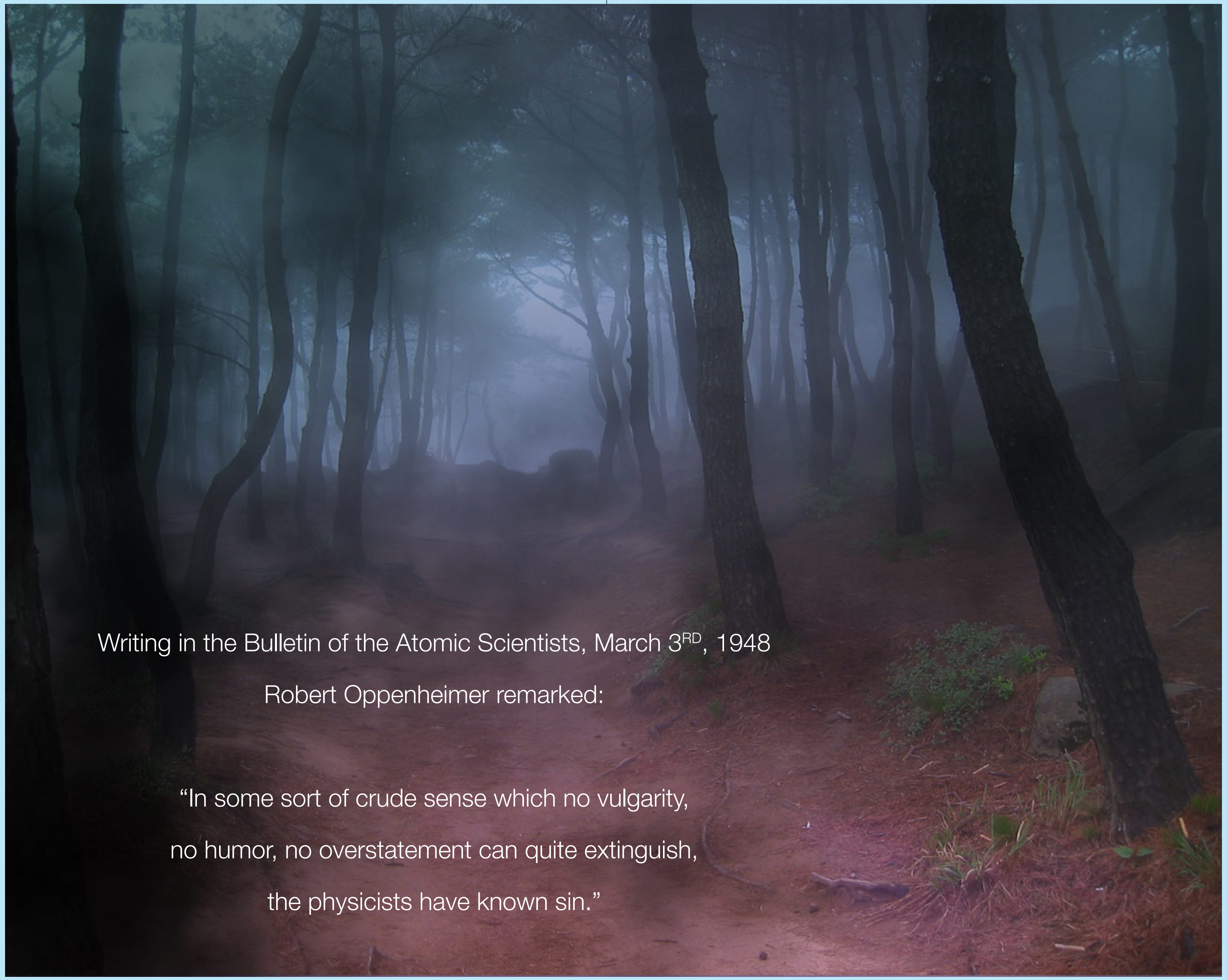
So, for Joy, is nanotechnology. For most scientists, however, the case is rather that of physicists in the 1930s, aware but sceptical of the prospect of the large-scale release of energy from the atomic nucleus, but almost without exception committed to exploring the exciting new world, and professional opportunities, opened up by quantum mechanics. Even after the discovery of fission in 1938, many prominent physicists, including Niels Bohr, were extremely dubious that a practical, deliverable weapon could be built. The thing to do was to press on, work hard to make sure of the facts, and hope the bomb would prove impossible.

Part of the motivation for pressing on, of course, was fear of Hitler getting the bomb first. But, assuming the risks of nanotechnological mass destruction became more widely accepted, what would the comparable fear be today? Pre-eminently, terrorism. Terrorists, however, can only hope to acquire new means of mass destruction in the same way they pursue nuclear, chemical and biological WMD - by pilfering and diverting from a highly-developed knowledge-base and infrastructure. In Joy's view, precisely such a 'gift' is presently being assembled and wrapped, generously funded and uncritically supported, and in the almost complete absence of mainstream political or wider democratic scrutiny or participation. 'We' are sowing the wind we all may reap.

Options for an Inner Space Treaty

There are two basic options for designing a possible arms control approach to the mass-destructive potential of nanotechnology. Both, of course, will be stillborn in the absence of a recognition by government, business and science - the 'strategic triad' of contemporary decision-making - that serious dangers exist. Such initial pressure for action cannot realistically be expected to come from within the structurally reactive and reflective arms control diplomatic community.

Let us assume, however, that growing public concern and increasingly troubling scientific results combine to push the issue onto a future agenda. We are immediately confronted with a decisive choice, so familiar to followers of myriad disarmament and non-proliferation discussions: what is our goal, abolition or regulation? Is the fundamental danger what 'others' might do with 'our' technology, or is the real problem the technology itself? It is possible to construct an arms control regime based on the logic of either conclusion; but it is not possible to merge both approaches.



Given the huge investment now flowing into nanotechnology, allied to the vast practical and financial gains on offer and the correspondingly large numbers of scientists likely to be employed in the new field, the probability is that a regime of control and restraint will acquire a compelling logic, banishing the 'chimera' of abolition to the shadows. If so, a rough transposition of the Outer Space Treaty - allowing only for obvious changes of reference and context - could quickly yield the broad brush parameters of an Inner Space Treaty seeking to ensure the peaceful exploitation, rather than the non-exploitation, of the nanosphere.

Such a treaty would mark a giant political leap forward from today's effectively unregulated mass of governmental, academic and commercial projects. The critical issue would then become one of effective practical implementation. How, for example, could the nature, scope, intention and possible application of inner-space research be ascertained and verified? How would violations be detected and transgressors corrected? Where would the line be drawn, and by whom, between defensive and offensive military nanotechnology? How could adequate monitoring and inspection of commercial nanotechnology be reconciled with the demands of competitiveness and confidentiality?

Such dilemmas and tensions are currently dogging the debate over the best means of strengthening the chemical and biological weapons regimes. Indeed, as mentioned above, the incursion into chemistry and biology of increasingly sophisticated techniques and processes of atomic and genetic engineering is already promising to destabilise many traditional arms control strategies and remedies. Until this new engineering revolution takes firmer shape, with its capacities and limits more clearly defined, how can we construct a regime of control and restraint around it, either in the CBW-area or under the remit of a new 'inner space' accord? But if we wait for the results of "*a wonderful free-for-all of discovery*" to become clear, then what are the chances of introducing timely and effective controls, rather than securely locking the empty stable?

As a radical alternative, what would an abolitionist treaty look like? Instead of reserving the nanosphere for peaceful human exploitation, it would seek its preservation as a natural 'wilderness' environment, treating any exploitation as a criminal violation of sanctuary. Again, though, if the elaboration of such a radical and ambitious regime waits on events, it will soon be overtaken by them, irremediably swamped by the sheer scale of ongoing nanotechnological colonization, mining, drilling, construction, etc.

Indeed, is there yet time for either version of an 'inner space' regime to be drawn up and introduced? Although some damage has already been done, it still seems fair to describe the nanotechnology revolution as in its infancy. The fact, as Oppenheimer once stated, that scientists have "*known sin*", is no reason - as Rabi and Fermi bravely argued with regard to the H-bomb - for the 'sinning' to continue, or reach a new level.

Conclusion

The danger of new means of mass destruction emerging from the development of nanotechnology is, by definition, as yet neither present nor clear. By the time it is, it may be too late to either eliminate or control. While there is no realistic possibility of early arms control negotiations to tackle the threat, the international community should at least take cognizance of the issue - in all its aspects, to use the appropriate diplomatic term for far-reaching, open-ended and open-minded deliberation.

As part of its establishment by a United Nations Special Session on Disarmament in 1978, the Conference on Disarmament (CD) in Geneva was provided with a wide-ranging list of items for possible pursuit. One of the items, dormant ever since, was: '*New Types of Weapons of Mass Destruction and New Systems of Such Weapons*'. Action to prevent the emergence of new means of mass destruction has, thus, a place already set for it at the diplomatic table.

Given its current tensions and deep stalemate, the CD is an impractical suggestion as a forum for initiating preliminary discussions on the international security implications of nanotechnology. The real issue, however, is not where but whether such discussions take place. In the name of our common humanity, and for the sake of our common and beautiful home, they must.

Notes and References

1. Given the potential scale of devastation brought into view by nanotechnology, it is tempting to move beyond the designation weapons of mass destruction and coin a new phrase - weapons of global destruction (WGD) - to better describe and convey the threat. I have shied away from doing so, however, for four reasons: 1) it may be possible to develop nanotechnological, or nanotechnologically-enhanced, weapons capable of causing mass destruction on the scale of nuclear, chemical or biological weapons, but not global destruction in the sense of irreparable, comprehensive annihilation of life on the planet; 2) it may conversely be the case that the irreparable, comprehensive annihilation of life on the planet could be inadvertently caused by nanotechnological devices, entirely outside of a military or terroristic context; 3) the threat posed to the planet by the three current categories of mass destruction - particularly nuclear weapons - is so severe that a new label connoting a qualitatively more severe threat is, certainly at this stage, premature and misleading; and 4) nanotechnology is likely to play a key role in rendering even more dangerous and repellent all three existing categories of mass destruction, particularly biological weapons, making distinctions between nuclear, chemical and biological weapons on the one hand, and nanotechnological weapons on the other, spurious and unhelpful. It may be, of course, that nanotechnology, if unchecked, will form part of a process of technological innovation leading to a spectrum of weapons better understood and described as WGD than WMD.

2. 'There's Plenty of Room at the Bottom', lecture by Richard Feynman to the American Physical Society, California Institute of Technology (Caltech), December 29, 1959. Feynman, who worked at Los Alamos during World War II, makes no reference in his lecture to the possible military applications of atomic engineering, stressing with customary optimism the potential benefits: "I am not afraid to consider the final question as to whether, ultimately - in the great future - we can arrange the atoms the way we want; the very atoms, all the way down! ... Up to now, we have been content to dig in the ground to find minerals. We heat them up and do things on a large scale with them, and we hope to get a pure substance with just so much impurity, and so on. But we must always accept some atomic arrangement that nature gives us. ... What could we do with layered structures with just the right layers? What would the properties of materials be if we could really arrange the atoms the way we want them? ... I can't see exactly what would happen, but I can hardly doubt that when we have some control of the arrangement of things on a small scale, we will get an enormously greater range of possible properties that substances can have, and of different things that we can do." Emphases in the original. For the full text of the lecture, see the California Institute of Technology, http://www.its.caltech.edu/~feynman.

3. The scanning tunnelling microscope was developed in 1981 by Gerd Binnig and Heinrich Rohrer at the IBM Research Laboratory in Zurich. Binning and Rohrer received the Nobel Prize for Physics for the invention in 1986. In 1990, Donald Eigler and Erhard Schweizer, using an STM at IBM's Almaden Research Laboratory in San Jose, California, arranged 35 xenon atoms to spell out three letters. The letters, naturally, were I, B, and M. In the years since, Eigler has been engaged in 'drawing' ever-more substantial atomic 'pictures'. An extraordinary 'STM image gallery' of 'works' by Eigler and his colleagues can be viewed at http://www.almaden.ibm.com/vis/stm/catalogue.html.

4. See http://www.nano.gov for the official NNI website.

5. According to the US National Science Foundation (NSF), global government spending on nanotechnology in FY 2001, excluding the United States, was $835 million, up from $316 million in 1997, the first year the NSF provided an estimate. See Gary Stix, 'Little Big Science', Scientific American, special issue on nanotechnology, September 2001 (http://www.sciam.com).

6. Speech by President William J. Clinton at the California Institute of Technology on January 21, 2000. In his remarks, the President invoked the optimistic ghost of Richard Feynman: "Caltech is no stranger to the idea of nanotechnology - the ability to manipulate matter at the atomic and molecular level. Over 40 years ago, Caltech's own Richard Feynman asked, 'what would happen if we could arrange atoms one by one the way we want them?'"

7. 'National Nanotechnology Initiative: Leading to the Next Industrial Revolution', White House Fact Sheet, January 21, 2000. The Fact Sheet lists seven "potential breakthroughs" anticipated over the next quarter-century: "the expansion of mass storage electronics to multi-terabit capacity that will increase the memory storage per unit surface a thousand fold"; "making materials and products from the bottom-up, that is, by building them up from atoms and molecules"; "developing materials that are 10 times stronger than steel but a fraction of the weight"; "improving the computer speed and efficiency of miniscule transistors and memory chips by factors of millions"; "using gene and drug delivery to detect cancerous cells by nanoengineered...contrast agents or target organs in the human body"; "removing the finest contaminants from water and air to promote a cleaner environment and potable water", and; "doubling the energy efficiency of solar cells". In addition to this sweeping vision of technology on the march, the Fact Sheet promises that the "impact nanotechnology has on society from legal, ethical, social, economic, and workforce preparation perspectives will be studied". However laudable this sense of broader context, however, the language is strikingly auto-suggestive, in effect directing the studies to consider what the impact of a massive government investment in nanotechnology is likely to be, rather than whether such an investment should be made.

8. There are currently ten US government partners in the NNI. In descending order of funding received in FY 2002, they are: National Science Foundation ($199 million); Department of Defense ($180 million); Department of Energy ($91.1 million); National Aeronautics and Space Administration (NASA - $46 million); National Institutes of Health ($40.8 million); National Institute of Standards and Technology ($37.6 million); Environmental Protection Agency (EPA - $5 million); Department of Transportation ($2 million); US Department of Agriculture ($1.5 million); Department of Justice ($1.4 million). The major recipient - the NSF - is entrusted to conduct a wide range of basic research under the heading 'Nanoscale Science and Engineering'. The major categories of this research are: biological sciences; computer and information science and engineering; engineering; geosciences, and; mathematics and physical science.

9. FY 2002 budget request, http://www.nano.gov/2002budget.html.

10. 'MIT to make "nanotech" Army wear', Tiffany Kary, CNET News.com, March 14 (2:39 PM), 2002. For the MIT press release quoted in the report, see 'Army selects MIT for $50 million Institute to use nanomaterials to clothe, equip soldiers,' March 13, 2002, http://www.mit.edu/newsoffice/nr/2002/isn.html. For a US Army summary, see 'Army teams with Massachusetts Institute of Technology (MIT) to establish Institute for Soldier Nanotechnology', News Release R-02-011, March 13, 2002. MIT has also published twenty 'questions and answers' concerning the project. Question 18 - "What is your response to critics who say universities are being turned into think tanks for the military?" - is answered as follows: "As a vast training bed that captures lessons learned exceptionally well, runs whole bases dedicating to educating men and women, and produces soldiers who are inspired by our nation's values and ideals, there is much that the military can share and shares in common with our nation's universities. It is in everyone's best interest that the military and academic institutions collaborate. It is also in everyone's best interest that ideas from academia, the entertainment industry and the military be improved through the rigors of scientific research." See 'Institute for Soldier Nanotechnology (ISN): Questions and Answers', MIT News Release, March 13, 2002, http://www.mit.edu/newsoffice/nr/2002/isnqa.html.

11. Charles M. Lieber, 'The Incredible Shrinking Circuit', Scientific American, September 2001. After much sober analysis, the article finishes with a flourish: "Although substantial work remains before nanoelectronics makes its way into computers, this goal now seems less hazy than it was even a year ago. As we gain confidence, we will learn not just to shrink digital microelectronics but to go where no digital circuit has gone before. Nanoscale devices that exhibit quantum phenomena, for example, could be exploited in quantum encryption and quantum computing. The richness of the nanoworld will change the macroworld."

12. George M. Whitesides and J. Christopher Love, 'The Art of Building Small', Scientific American, September 2001.

13. A. Paul Alivisatos, 'Less is More in Medicine', Scientific American, September 2001. Cautious and tentative throughout, the paper ends with an intoxicated survey of prospects: "What...marvels might the future hold? Although the means to achieve them are far from clear, sober nanotechnologists have stated some truly ambitious goals. One of the 'grand challenges' of the National Nanotechnology Initiative is to find ways to detect cancerous tumors that are a mere few cells in size. Researchers also hope eventually to develop ways to regenerate not just bone or cartilage or skin but also more complex organs, using artificial scaffoldings that can guide the activity of seeded cells and can even direct the growth of a variety of cell types. Replacing hearts of kidneys or livers in this way might not match the fictional technology of Fantastic Voyage, but the thought that such medical therapies might actually become available in the not so distant future is still fantastically exciting." At no point does Alivisatos address the potential misuse of these techniques and methods.

14. K. Eric Drexler, 'Machine-Phase Nanotechnology', Scientific American, September 2001.

15. Ray Kurzweil, The Age of Spiritual Machines, Penguin Books, 1999, pp. 141-142. Emphasis in the original.

16. K. Eric Drexler, Engines of Creation, Anchor Books, 1986, p. 174.

17. The same potential for misuse, of course, applies across the spectrum of modern biotechnologies based on genetic engineering and modification. The risk of unintended consequences - a supercrop producing superweeds, for example - is itself considerable; the potential for intended consequences - qualitatively new biological weapons - is perhaps even greater. For details of the debate over the impact of biotechnology on efforts to strengthen the Biological Weapons Convention, see Jenni Rissanen, 'BWC Report', Disarmament Diplomacy No. 62, pp. 18-32.

18. 'Why the Future Doesn't Need Us', Bill Joy, Wired, April 2000 (http://www.wired.com).

19. I don't interpret Joy as placing the entire onus for sounding the alarm on scientists. Nevertheless, he does stress the obviously especial responsibility of practitioners in a new field to provide honest assessments of risk and dangers to their paymasters - whatever the risk and dangers to their careers. Once the field is well-established, scientists' qualms or concerns are much easier to ignore - why, after all, did they not say so before? This was certainly the well-documented experience of many physicists involved in the Manhattan Project, lobbying frantically after the bomb was built to prevent its unannounced use against a Japanese civilian target - a scenario which, to most of them, would have sounded nightmarish beyond crediting at the outset of the Project. In contrast, there is clear, though contested, evidence, that the majority of scientists working under the direction of the Nazi regime - most importantly, Werner Heisenberg - deliberately used their influence to persuade the authorities not to engage in serious weapons work. Whatever the exact motivation and sequence of events, the broader point is that a unique window of opportunity can sometimes open in the formative stages of a major new technological enterprise for scientists to lobby either for or against its pursuit, and so to help determine, perhaps critically, the scale and intensity of the endeavour. For discussion of the radically different situation and approaches of atomic physicists in America and Germany in World War II, see Robert Jungk, Brighter Than a Thousand Suns, Penguin Books, 1970 edition, especially pp. 175-191 & pp. 201-217; Thomas Powers, Heisenberg's War: The Secret History of the German Bomb, Da Capo Press, 2000, especially pp. 478-484; and Richard Rhodes, The Making of the Atomic Bomb, Touchstone, 1988, especially pp. 749-788.

20. Gary Stix, 'Little Big Science', Scientific American, September 2001.

21. 'Why the Future Doesn't Need Us', Bill Joy, Wired, April 2000.

22. For the report, supporting documents and debates of the GAC, see Rhodes, The Making of the Atomic Bomb, pp. 776-770. A sceptical response to Fermi and Rabi's description of the H-bomb as "necessarily an evil thing in any light" would be to say that the non-use of ther-

monuclear weapons since 1949 proves such a dramatic characterisation to have been overblown. The prospect of global destruction through a full-scale nuclear conflict has not yet been lifted, however, and is sufficiently appalling to make a 53-year time period startlingly insignificant. The only point at which one could conclude that the cloud had passed would be with the advent of a nuclear-weapon-free world - an objective to be sought in part because of the irreducible moral illegitimacy of thermonuclear weapons. Fermi and Rabi would perhaps regard considerations such as the purported success of deterrence, or the prevention of Cold War meltdown into full-scale conflict, as good examples of the kind of “light” in which the issue should not be considered.

23. Up to his death in 1937, Ernest Rutherford, the leading pioneer of modern atomic physics, believed in the impracticality even of generating useable energy directly from atoms. As quoted in a famous article in The Times on September 12, 1933, Rutherford noted that bombarding heavy elements with neutrons and other particles “was a very poor and inefficient way of producing energy, and anyone who looked for a source of power in the transformation of the atoms was talking moonshine”. See Rhodes, The Making of the Atomic Bomb, p. 27.

24. In his survey of the attitude of physicists in the 1930s to the possibility of atomic weapons, Robert Jungk names only one scientist who walked away from a bright professional future. Jungk quotes the English crystallographer Kathleen Lonsdale as arguing that scientific “responsibility cannot be shirked” for the “criminal or evil” application of research, “however ordinary the work itself may be”. He then writes: “Only a few scientific investigators in the Western world have in fact acted on this principle. Their honesty obliged them to risk their professional future and face economic sacrifices with resolution. In some cases they actually renounced the career they had planned, as did one of Max Born’s young English assistants, Helen Smith. As soon as she heard of the atom bomb and its application, she decided to give up physics for jurisprudence.” The case is doubly interesting given Born’s decision, upon leaving Nazi Germany, to remain a physicist but refuse to take part in any active weapons work. In the opinion of the author of this paper, Smith ranks as one of the unsung heroes of the history of scientific conscientious objection. See Jungk, Brighter Than a Thousand Suns, p. 261.

25. Bohr believed an atomic bomb, at least of devastating effect, would be rendered impractical by the scale of the effort involved in producing sufficient quantities of the kind of uranium, the naturally rare isotope U-235, required. According to Edward Teller, Bohr told scientists at Princeton University in 1939 that “it can never be done unless you turn the United States into one huge factory”. Visiting Los Alamos in 1943, Bohr admitted he had been both wrong and right: wrong in that he hadn’t foreseen the production of highly-fissionable plutonium from burning commonplace uranium (U-238); right in the scale of industrial effort required to produce sufficient quantities of both plutonium (used to destroy Nagasaki) and U-235 (used to destroy Hiroshima). See Rhodes, The Making of the Atomic Bomb, p. 294. It is salutary to consider what comparable assumptions may be built into the thinking of prominent scientists today who see no compelling cause for concern about the capacity of nanotechnology to produce new means of mass destruction. In one respect, the situation is perhaps more frightening, as a much lesser military-industrial effort than the Manhattan Project may be required to produce and deliver nanotechnological WMD. Might there not also be the possibility of an equivalent to plutonium: a sudden discovery which makes, for example, uncontrollable nanorobotic proliferation eminently more feasible?

26. ‘The Art of Building Small’, George M. Whitesides and J. Christopher Love, Scientific American, September 2001.

27. This formulation clearly suggests the violatory quality of all atomic experimentation and energy production involving penetration into the atomic interior, i.e. bombardment of the nucleus. The logical extension of an Inner Space Treaty premised on a defence of atomic sanctuary would indeed be the abolition of all nuclear weapons, nuclear energy and nuclear research activities - just as the exploitation of the atomic and molecular interior for engineering purposes is a logical extension of the exploitation of that environment in pursuit of military, scientific and industrial advantage.

28. Writing in the Bulletin of the Atomic Scientists, March 3, 1948, Oppenheimer remarked: “In some sort of crude sense which no vulgarity, no humor, no overstatement can quite extinguish, the physicists have known sin.”

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THREATS TO THE NON-PROLIFERATION REGIME: FOURTH GENERATION NUCLEAR WEAPONS

Nuclear proliferation is traditionally based on the techniques of uranium enrichment and plutonium separation. A third ingredient, the mechanism of boosting, has acquired a fundamental role in modern, compact and efficient warheads: a very small (*around two grams*) quantity of a deuterium-tritium mixture (DT) is placed in the core of the plutonium pit before the detonation (tritium is a radioactive substance, with a half-life of 12 years, and must be continuously produced). The implosion and priming of the chain reaction ignites the nuclear fusion reaction of the DT mixture (*whose contribution to the yield is negligible*), generating a strong flux of neutrons which, from the inside, enhances and exhausts the fission of plutonium before the warhead disassembles. Tritium technology is complex, since it is an extremely volatile and radioactive gas: it is produced bombarding lithium-6 with neutrons (*typically in a nuclear reactor, as India and Pakistan have done*).

IT'S CRITICAL TO NOTE:

It is important to remark that the non-proliferation regime established since 1970 only deals with warheads based on the chain reaction in *uranium or plutonium*, and suffer from additional and severe limitations. In fact, not only the START-II and the CTBT never entered into force, but the latter bans only full-scale nuclear tests, again, based on *uranium and plutonium.*

CLASSIFIED

In, “Problems With The Stockpile Stewardship”, Nature, 386, April 17th, 1997, p. 646, Ray E. Kidder states:

“*The relevance of the National Ignition Facility to nuclear weapons science is that the states of matter produced, and the physical processes involved, are similar to those that govern the behavior of nuclear weapons. As a result, computer programs used in Internal Confinement Fusion research have much in common with those used in nuclear weapons design. The more powerful of these are therefore classified, at least at the three US nuclear weapons laboratories.*”

note the plane in the center of this picture

A third ingredient,

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of the plutonium pit

before the detonation

A BRIEF HISTORY OF FUSION ENERGY RESEACRH

The idea of using human-controlled fusion reactions was first made practical for military purposes, in nuclear weapons. In a hydrogen bomb, the energy released by a fission weapon is used to compress and heat fusion fuel, beginning a fusion reaction which can release a very large amount of energy. The first fusion-based weapons released some 500 times more energy than early fission weapons.

Civilian applications, in which explosive energy production must be replaced by a controlled production, were developed later. Although it took less than ten years to go from military applications to civilian fission energy production, it was very different in the fusion energy field, more than fifty years having already passed without any energy production plant being started up. Yet massive explosive devices have been detonated.

> design and development skills are allowed to atrophy, and only those skills required to remanufacture weapons according to their original specifications are preserved

Registration of the first patent related to a fusion reactor by the United Kingdom Atomic Energy Authority, the inventors being Sir George Paget Thomson and Moses Blackman, dates back to 1946. Some basic principles used in ITER experiment are described in this patent: toroidal vacuum chamber, magnetic confinement, and radio frequency plasma heating.

Inventor of the Cathode Ray Tube Television, Philo T. Farnsworth patented his first Fusor design in 1968, a device which uses the Inertial electrostatic confinement principle to achieve controlled fusion. Although the efficiency was very low at first, fusion could be achieved using a '*lab bench top*' type set up for the first time, at minimal cost.

Towards the end of the 1960s, Robert Hirsch designed a variant of the Farnsworth Fusor known as the Hirsch-Meeks fusor. This variant is a considerable improvement over the Farnsworth design, and is able to generate neutron flux in the order of one billion neutrons per second. This type of fusor found its first application as a portable neutron generator in the late 1990s. An automated sealed reaction chamber version of this device, commercially named Fusionstar was developed by EADS but abandoned in 2001. Its successor is the NSD-Fusion neutron generator.

In the magnetic confinement field, the theoretical works fulfilled in 1950-1951 by I.E. Tamm and A.D. Sakharov in Soviet Union, laid the foundations of the tokamak. Experimental research of these systems started in 1956 in Kurchatov Institute, Moscow by a group of Soviet scientists lead by Lev Artsimovich. The group constructed the first tokamaks, the most successful of them being T-3 and its larger version T-4. T-4 was tested in 1968 in Novosibirsk, conducting the first quasistationary thermonuclear fusion reaction ever.

The U.S. fusion program began in 1951 when Lyman Spitzer began work on a stellarator under the code name Project Matterhorn. His work led to the creation of the Princeton Plasma Physics Laboratory, where magneticallly confined plasmas are still studied. The stellarator concept fell out of favor for several decades afterwards, plagued by poor confinement issues, but recent advances in computer technology have led to a significant resurgence in interest in these devices. Nevertheless, a tokamak device was selected as the design concept for ITER, which will be completed sometime in the next decade (*completion goal - 2019*) with the hope of creating a burning plasma and proving the feasibility of a commercial fusion reactor. A "*wires array*" was used in Z-pinch confinement, during the building process. The Z-pinch phenomenon has been known since the end of the 18th century. Its use in the fusion field comes from research made on toroidal devices, initially in the Los Alamos National Laboratory right from 1952 (*Perhapsatron*), and in the United Kingdom from 1954 (*ZETA*), but its physical principles remained for a long time poorly understood and controlled. The appearance of the "*wires array*" concept in the 1980s allowed a more efficient use of this technique.

Although laser use in order to initiate fusions had been considered as early as immediately after the invention of the laser itself in 1960, serious ICF experiments began in the early 1970s, when lasers of the required power were first designed. The technique of implosion of a microcapsule irradiated by laser beams, the basis of laser inertial confinement, was first suggested in 1962 by scientists at Lawrence Livermore National Laboratory.

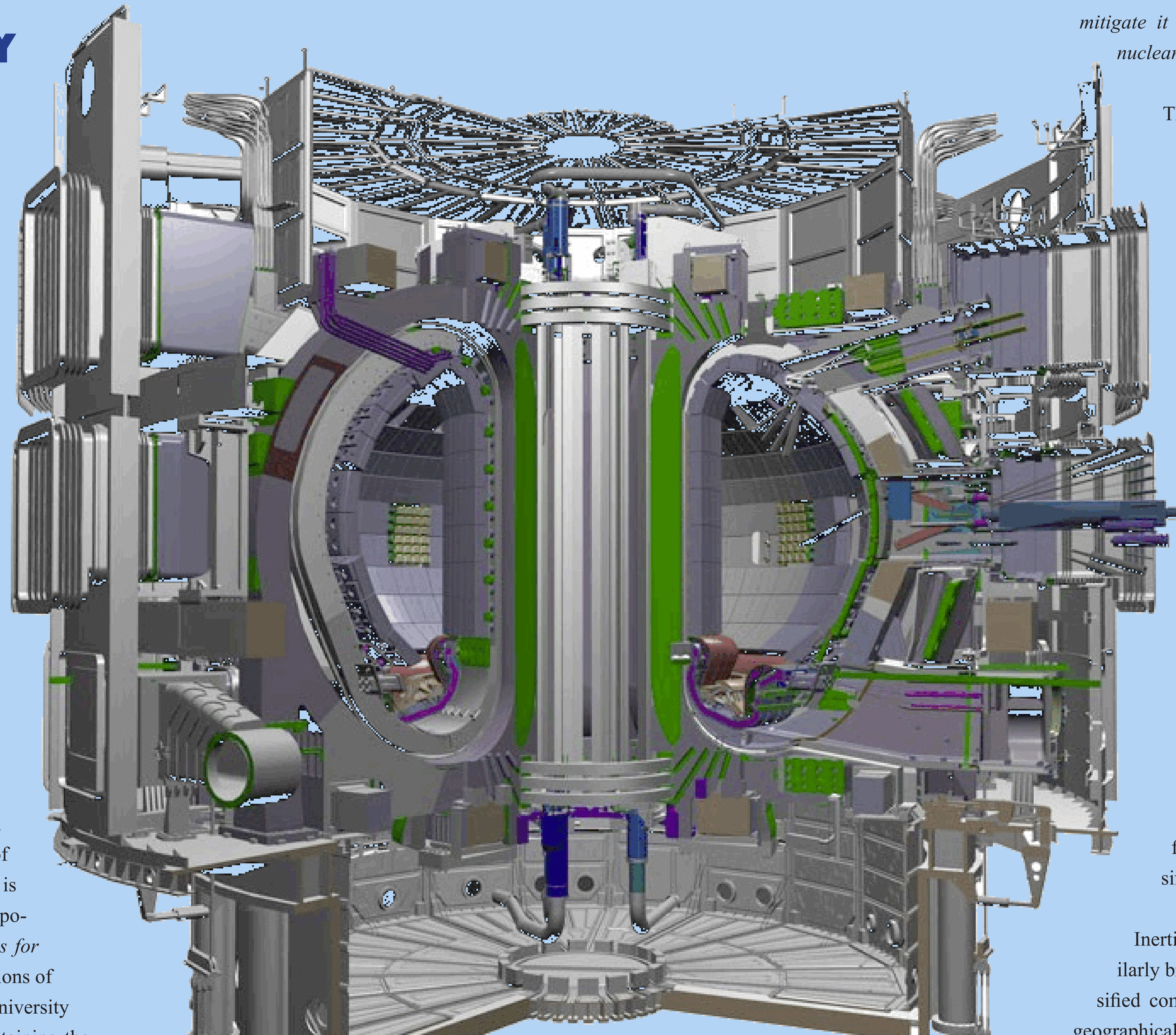
In April 2005, a team from UCLA announced it had devised a novel way of producing fusion using a machine that "fits on a lab bench", using lithium tantalate to generate enough voltage to smash deuterium atoms together. However, the process does not generate net power. See Pyroelectric fusion.

NUCLEAR PROLIFERATION

Although fusion power uses nuclear technology, the overlap with nuclear weapons technology is small. Tritium is a component of the trigger of hydrogen bombs, but not a major problem in production. The copious neutrons from a fusion reactor could be used to breed plutonium for an atomic bomb, but not without extensive redesign of the reactor, so that clandestine production would be easy to detect. The theoretical and computational tools needed for hydrogen bomb design are closely related to those needed for inertial confinement fusion, but have very little in common with (*the more scientifically developed*) magnetic confinement fusion.

FUSION POWER AS A SUSTAINABLE ENERGY SOURCE - ITER

Fusion power is often described as a "*clean*", "*renewable*", or "*sustainable*" energy source. Large-scale reactors using neutronic fuels (e.g. ITER at right) and thermal power production (*turbine based*) are most comparable to fission power from an engineering and economics viewpoint. Both fission and fusion power plants involve a relatively compact heat source powering a conventional steam turbine based power plant, while producing enough neutron radiation to make activation of the plant materials problematic. The main distinction is that fusion power produces no high-level radioactive waste (*though activated plant materials still need to be disposed of*). There are some power plant ideas which may significantly lower the cost or size of such plants, however research in these areas is nowhere near as advanced as in tokamaks.



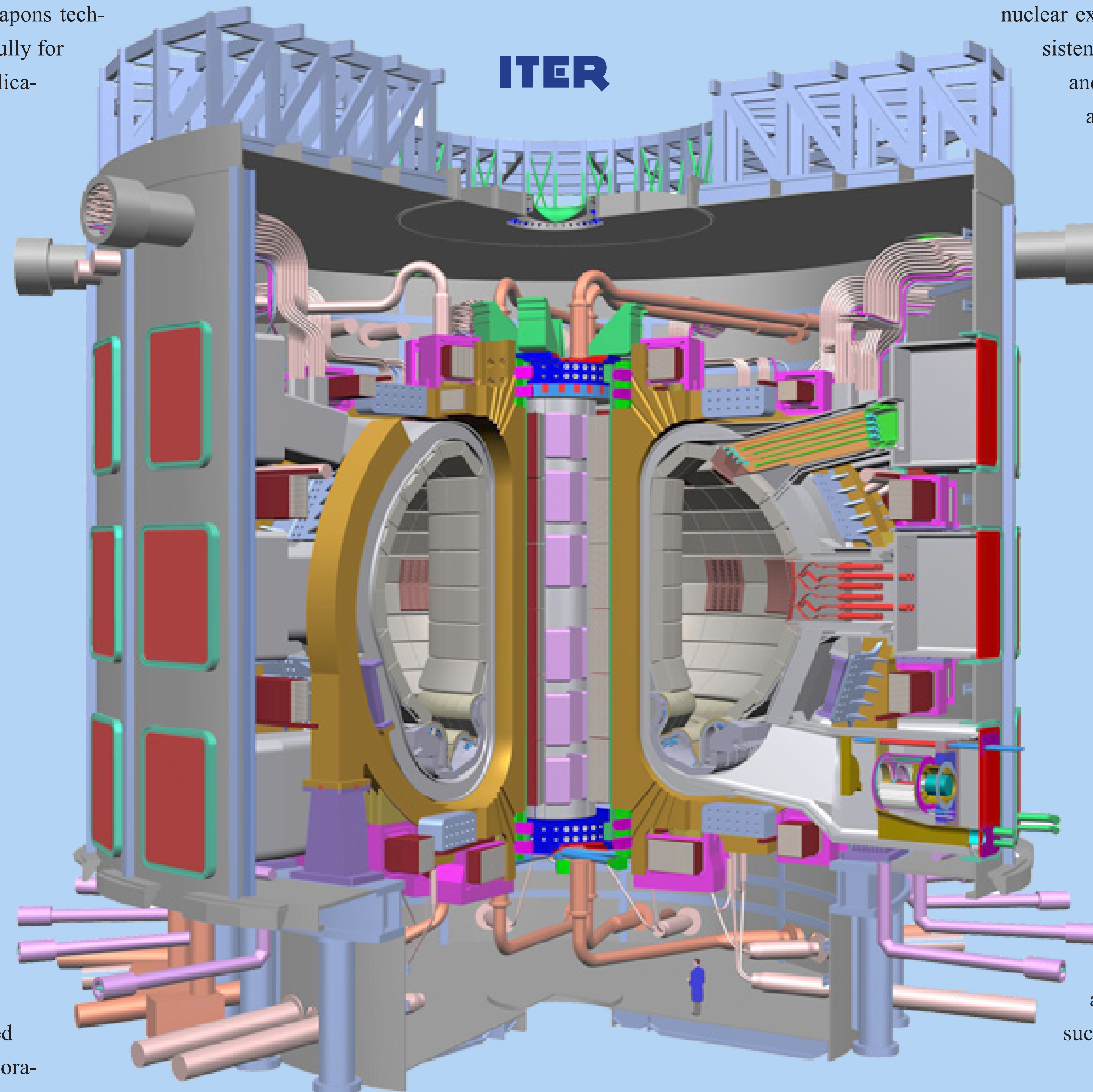
ITER

CONCLUSIONS

A strong possibility exists that the United States is poised to repeat the errors of the Atoms for Peace Program in the 1950's, in which a torrent of public relations regarding the "*peaceful atom*" enveloped a release of sensitive nuclear fuel cycle technology that was intended politically to counterbalance the U.S. decision to abandon the goals of disarmament and international control of atomic energy in favor of massive nuclear weapons buildup. It is difficult to avoid the conclusion that the SSBS program has the potential to develop into as big a proliferation debacle as "*Atoms for Peace*." In a little noticed, unpublished dissent from the conclusions of the Drell SSBS Report in which he participated, Washington University physicist Jonathan Katz contrasted the SBSS approach to maintaining the U.S. deterrent with an approach he called "*curatorship*." Under this strategy, new experimental facilities such as NIF are not built, "*design and development skills are allowed to atrophy, and only those skills required to remanufacture weapons according to their original specifications are preserved*." Curatorship is preferable to SBSS, Professor Katz argued, because "*the chief nuclear danger in the present world is that of proliferation, and stewardship will exacerbate this danger, while curatorship will mitigate it while preserving our existing nuclear forces.*"

The construction and operation of the National Ignition Facility (NIF) and related facilities would not be cheap. More important are the consequences for the present and future danger of proliferation. NIF will bring together the weapons and unclassified communities. People will rub elbows, share facilities, collaborate on unclassified experiments, and communicate their interests and concerns to each other. Information and understanding will diffuse from the classified to the unclassified world, without any technical violation of security. The desire to achieve renown and career success by publication in the open literature will diffuse from the unclassified to the classified world.

Inertial (*chiefly laser*) fusion has similarly brought its classified and unclassified communities into intellectual and geographical contact over the last 25 years. The consequence has been the declassification of many nuclear weapon concepts and information. It is common knowledge that there is a great deal of physics in common between inertial fusion and nuclear weapons. The



unclassified inertial fusion community has reinvented weapons technology, and the classified community has pressed successfully for declassification of formerly classified concepts, some applicable to inertial fusion and some not so applicable.

This process would continue at NIF, which would provide a facility and funding for the unclassified world to rediscover nuclear weapons physics and (*implicitly*) to develop the understanding and computational tools required to design weapons. This reduction of the barriers to proliferation of both fission and thermonuclear weapons is not in the national interest.

In addition to the broad proliferation consequences of the SBSS raised in this paper, as yet unanswered questions unavoidably present themselves concerning specific pulsed power and HE-driven approaches to fusion. If such experiments are not prohibited under the NPT or CTBT, with or without any interim limit on fusion neutron output, who gets to conduct such experiments? Absent further clarification, it appear that Germany, a non-weapon state under the NPT, and possibly others, are reserving the legal "*right*" -- while perhaps not any immediate intention -- to do so. Should the international community therefore acquiesce in the conduct of such experiments by any non-weapon state?

In their zeal to create a "*technically challenging*" program in nuclear weapons simulation research to replace the perpetual cycle of nuclear weapons development and testing that historically had supported a lavish and cloistered research environment at the nation's nuclear weapons laboratories, the current managers of the U.S. nuclear weapons complex have confronted policymakers with a Hobson's choice between false alternatives – either buy the entire $4.5 billion "*virtual testing*" paradigm and absorb the self-inflicted proliferation risks that it entails, or lose confidence in stockpile reliability and safety by the middle of the next decade. As we have argued in this paper and elsewhere, this is a false choice, predicated on a concatenation of fallacies.

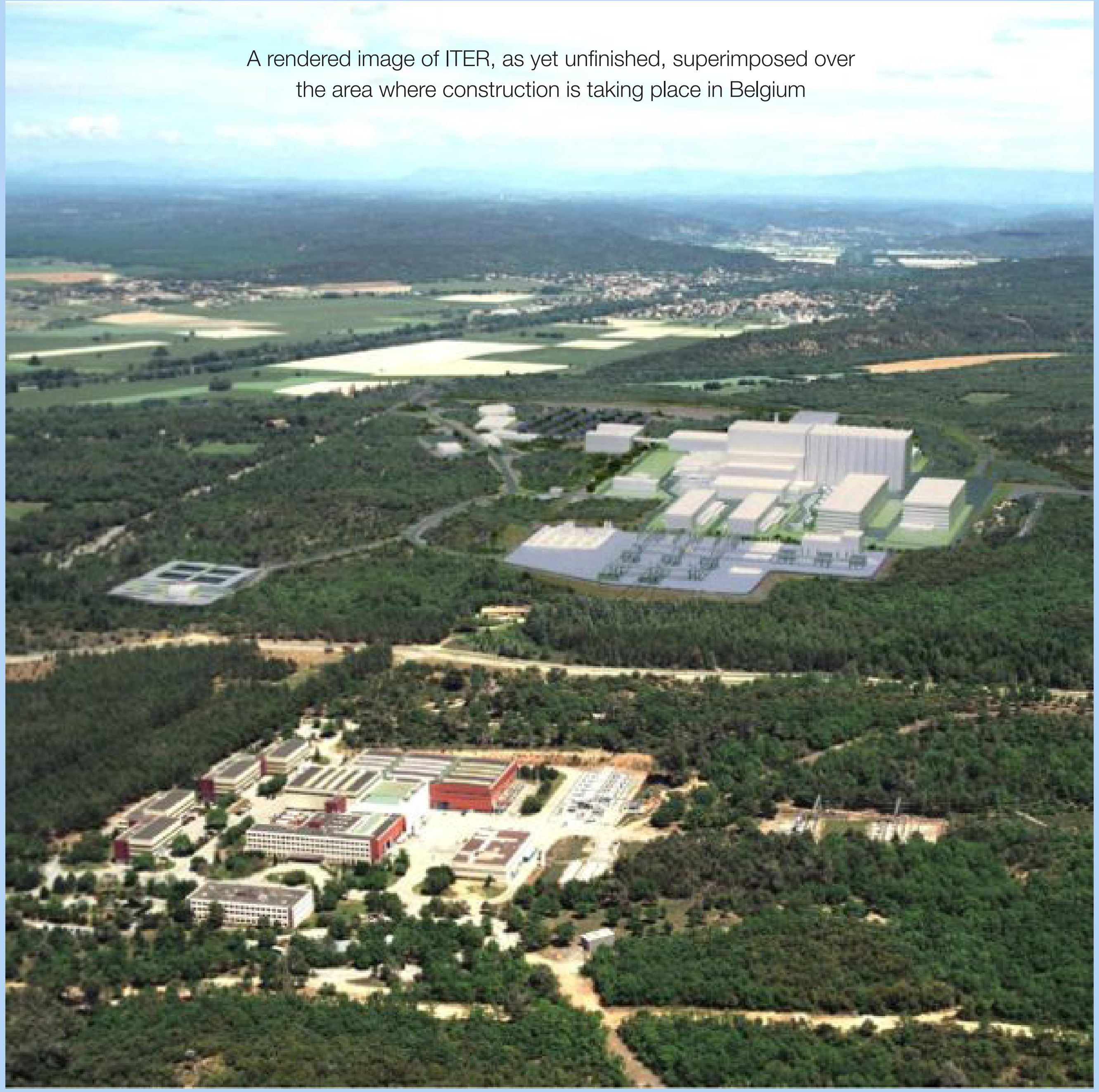
First, the record of the stockpile surveillance program shows that the nuclear explosive packages in operational U.S. nuclear weapons can be maintained – as opposed to developed or improved – over time without reliance on nuclear explosive testing. Hence stockpile "*stewardship*" that is consistent with the CTBT's avowed intent to constrain development and qualitative improvement of nuclear weapons need not, as a technical matter, seek to fashion a way around these constraints through an elaborate "*virtual testing*" program.

Second, it is not inherently necessary to predict (*through complex simulations*) the occurrence of aging effects and the point at which they cumulatively will begin to seriously degrade nuclear explosive performance -- it is necessary only to detect deterioration that exceeds, in the case of the nuclear explosive package, the previously demonstrated parameters associated with acceptable performance, or in the case of other components, the demonstrable parameters of acceptable performance, as the performance effects of "*aging*" on these components is not constrained by the existing database and can be exhaustively explored. While such an approach might result in a less than optimal schedule for remanufacture of the nuclear explosive package, we have seen no analysis that suggests that the incremental cost would even begin to approach the significant incremental cost of DOE's accelerated nuclear explosion simulation effort. Moreover, as the future stockpile decreases in size – one would hope dramatically so – any cost savings from optimizing schedules for remanufacture disappear as well, as these savings pale in comparison to the large capital investment and annual fixed costs of the SBSS program. But even if there were significant cost advantages from taking this approach, these must be weighed against the proliferation risks of the current program, and such a comparison finds DOE's current approach wanting.

Third, although the authors see no compelling reasons to do so, from a purely technical perspective, existing nuclear explosive packages can be integrated into new or modified warhead and bomb systems, and these systems in turn can be mated to new or modified delivery systems, without resort to the highly challenging but proliferation-prone "*first principles*" nuclear explosive simulation effort now being undertaken by DOE. In other words, under a CTBT many of the operational characteristics of nuclear weapon systems can be adapted – within the limits imposed by the certified performance envelopes of existing nuclear explosive packages – to changing military missions without incurring the considerable proliferation risks entailed by the DOE'S massive and increasingly unclassified "*science-based*" program of nuclear explosive simulations, weapon-physics, and fusion experiments. Improved casings, radars, altimeters, boost-gas delivery systems, neutron generators, detonators, batteries, integrated circuits, fuzing and arming systems, permissive action links – all can be developed and integrated into nuclear bomb and warhead systems without modifying the nuclear explosive package design.

Given these technical realities, there is a legitimate cause for wondering exactly what is driving the U.S. decisionmaking process toward unquestioning acceptance of the SBSS program's fiscal, technical, and proliferation risks. We have a tentative answer to this question, and it is largely institutional and political in nature. Because the various administrations have done so little to change the ways in which the U.S. defense bureaucracies are directed to think about the future roles and missions of nuclear weapons in support of U.S. security policy, the vigorous and politically potent self-preservation reflex of the U.S. nuclear weapons research and development complex has filled the policy void, fashioning a program that assures, in essence, that all status quo nuclear weapon design capabilities will be preserved, and where possible, even enhanced. The result is a hugely ambitious surrogate weapons R&D program that integrates greatly expanded computational capabilities, fundamental data gathering on constituent bomb materials and explosive processes, and integrated demonstrations of nuclear design code predictive capabilities in a range of powerful new experimental facilities.

All of this is ultimately justified, we are told, not by the present state of Russian or other nuclear threats to American and allied security, which have arguably diminished to their lowest level in five decades, but by two other factors: (1) the need to retain a robust nuclear deterrent "*hedge*" against an uncertain future in which something like the Cold War complex of nuclear weapon design capabilities might once again be needed; and (2) the need to retain a convincing and "*flexible*" nuclear deterrent to biological and chemical weapons use by so-called "*rogue nations.*" To the extent that the current bloated stewardship program relies on the latter justification, its proliferation impact takes on an acutely political as well as technical dimension: if the U.S. perceives the need for a nuclear deterrent to chemical-biological-radiological (CBR) weapons use, why shouldn't other nations facing similar and in some cases more immediate threats, likewise reach for a nuclear deterrent?



A rendered image of ITER, as yet unfinished, superimposed over the area where construction is taking place in Belgium

ITER project facts.

• ITER (International Thermonuclear Energy Reactor) is a joint international research and development project that aims to demonstrate the scientific and technical feasibility of fusion power.

• The aim of ITER is to show fusion could be used to generate electrical power, and to gain the necessary data to design and operate the first electricity-producing plant.

• The partners in the ITER project are the European Union (represented by EURATOM), Japan, the People's Republic of China, India, the Republic of Korea, the Russian Federation and the USA.

• The construction costs of ITER are estimated at five billion Euros over 10 years, and another five billion Euros are foreseen for the 20-year operation period.

• A tokamak is a machine producing a toroidal (doughnut-shaped) magnetic field for confining a plasma. It is one of several types of magnetic confinement devices and the leading candidate for producing fusion energy. ITER is a tokamak.

• ITER is a tokamak, in which strong magnetic fields confine a torus-shaped fusion plasma. The device's main aim is to demonstrate prolonged fusion power production in deuterium-tritium plasma.

• The ITER device is based on the tokamak concept, in which a hot gas is confined in a torus-shaped vessel using a magnetic field. The gas is heated to over 100 million degrees, and will produce 500 MW of fusion power.

• The idea for ITER originated from the Geneva superpower summit in November 1985 where Premier Gorbachov, following discussions with President Mitterrand of France, proposed to President Reagan that an international project be set up to develop fusion energy for peaceful purposes.

• ITER will produce about 500 MW (output power) of fusion power in nominal operation, for pulses of 400 seconds and longer. Typical plasma heating levels during the pulse are expected to be about 50 MW (input heating power), so power amplification (Q) is 10.

• The aim in the ITER design is to allay any concerns by compartmentalizing and minimizing any sources of airborne radioactivity (e.g. tritium, dust) into sufficiently small mutually exclusive amounts, and to physically arrange that they cannot be vented to the environment.

• If all goes well with the operation of ITER and the construction of the first electricity-generating plant that follows it, the first reliable commercially available electrical power from fusion should be available around 2045.

• ITER will consume about 16 kg (35.2 pounds) of tritium over its 20 year life, and thus need 17.5 kg to be delivered to the site taking account of radioactive decay. During the first 10 years of operation the need is about 7 kg.

• The construction of the ITER reactor began in the year 2009 and it will become operational in the year 2016 - 2019.

• ITER is more than just fusion energy sciences; it may well be the path forward for all of large-scale truly international science collaboration.

PART FIVE CONCLUSIONS

1. Nano technology and fusion-fission demolition devices the size of an apple and smaller is a stark reality that we all must deal with. Nano technology poses a distinct threat to the civilian population, especially in the wrong hands as can be seen by examining the events of September 11th, 2001.

THE IMAGE ON THE NEXT PAGE

This image was taken by a FEMA certified photographer before any excavation took place. You can see that these are rescue workers surveying the scene and they're walking on a 2.5 inch thick structural steel box column. Five inches of steel per side. The far right end of the column is cut clean and appears to have failed at a junction or connection point. It does not show the necessarily characteristic burning and melting of metal that would have to be concomitant with an energetic nano-compound burning, melting or exploding through the metal.

I can still see insulation on the box column at about 3 feet from the far right end, on the side facing the camera. It's an off-white color and has a fluffy look to it. I'm able to zoom this picture 7 times without any distortion. Many of the images in this eMagazine can be zoomed just the same or even more.

I see no evidence of conventional explosives or energetic nano-compound explosives or incendiaries in *any* of the images in this book or the 100s more that I have that aren't in this book. I own an extensive collection of extremely large, high quality, early FEMA Ground Zero images posted to the internet as public domain material in 2002 or so. Of course they're no longer available. They disprove the nano-energetic compound theory and we can't have that. I can't see evidence of explosives or incendiaries in any of the images. I've tried to post the images that provide the most credible and relevant evidence in this eMagazine.

PART SIX

THERMITE

Thermite patents from the 1940s are on the internet and we're not dealing with thermite here. Thermite is NOT an explosive. Energetic compounds need an explosive to be added to them if they are to have explosive properties or even be categorized as explosives. Otherwise, they are classified asincendiaries, fast burners. They burn in milliseconds and exhaust their fuel. That's why they're made at nano-scale, to increase burn speed. among other things.

It's important for me to express that I don't have a clue what place nano energetic compounds played on 911 or if they even played a part at all. Dr. Jones has a credibility gap not seen in the USGS ior Delta Group data and that's chain of possession of samples. Jones' samples are not secured chain of possession by any stretch.

I abhor the exchange of dialogue using terminology with flagrant disregard for meaning while expecting to have an intellectual discussions in the 911 truth movement as though thermite, super-thermite, nano-thermite, thermate, energetic compounds and metastable intermolecular compounds or sol gels all mean the same damned thing. They do not.

Thermite is an incendiary used as rocket fuel and in munitions cartridges. Thermite can only be an explosive if an explosive is added to it. If an explosive is not added to it and other non-explosive nano-elements are added it simply burns a little faster but it is still not classified as a military explosive. It MUST have an explosive element added to it to be classified as an explosive.

It's not that I don't believe that a nano-scale energetic compound was found by Dr. Stephen Jones in the dust at Ground Zero, NYC, or that it has a velocity of 300mps (*Harrit, 2011*). We know that the iron oxide rich and aluminum compound in a silica substrate at nano-scale found by Dr. Jones has a maximum velocity of 895mps (*peer reviewed 2011*). Dr. Jones' compound has a velocity of 300mps (*Jones 2010*). It's just that I don't believe it has the thermal capacity to cause the demolition we saw. Dr. Neils Harrit, in an email response to T. Mark Hightower and others, estimated between 29,000 and 144,000 metric tons of the energetic compound studied by himself, Jones, et al., would have been used based on his studies of the dust samples they have.

As I've said before, that would have required 100 days IF — 29,000 metric tons (*Dr. Harrit's low*) were moved by 1,500 tractor trailer loads (*that's how many trucks it would take to move 29,000 tons*) working round the clock unloading 1 metric ton crates from inside the trailer to the *final* destination every 15 minutes, non-stop. Over 300 days if they worked regular 8-hour union-scale day shifts, but that would be at 7 days a week without breaks. It's a flawed theory for many reasons, not just this one.

Yet it's a captivating theory is it not? No one ever heard of nano-thermite before and worse, no one has bothered to study it extensively or they would know it is entirely incapable of the demolition we saw. Imagine if everyone took the time to study nanoenergetics thoroughly. Perhaps using the Lawrence Livermore, Oak Ridge and Sandia web sites. Everyone would know. Nano-Thermite is just another 911, a Limited Hangout, a fraud on humanity.

The thermal capacity of energetic compounds with a velocity of 300mps (*even the maximum iron rich aluminum compound velocity by peer review, 895mps, is not enough*) is not enough to calcine 100,000 tons (*25% of the estimated concrete*) of concrete into a highly caustic dust similar to drain cleaner in less than 10 seconds as we all watched in awe as the sizzling clouds engulfed the city and enveloped everything in their paths; the clouds even spread out across the Hudson River. The images in this eMagazine show it clearly.
That's right. People 'heard' the clouds. They were sizzling as they passed. There were survivors who were running for their lives just on the very edge of the criticality of the event. They survived and told unimaginable stories. Yes, the clouds were described as '*sizzling*' and people were vaporized. This isn't energetic compounds.

Greater thermal capacity was required to turn the concrete to dust. Check with a physicist on the heat or thermal capacity necessary to calcine 100,000 tons of concrete into a highly caustic substance with the pH of drain cleaner in less than even a full 10 seconds time while also destroying the rest of two 100+ story steel buildings.

Everything that happened that day as regards the Twin Towers happened in less then 10 seconds per tower. The dust created in that very short period plays a key role in understanding what happened that day.

The dust is the ONLY evidence we have and the only evidence we'll ever have. More importantly, it's the only evidence we'll ever need.

That's one of the most important and crucial aspects of this event for me. 10 Seconds. All anomalies need to be accounted for in less then 10 seconds; the u-shaped girder that appears in this eMagazine for example, without creases, rips or tears on the long radius, along with numerous other known anomalies; everything needs to be accounted for in any theory that maintains full integrity within a ten second period. All of the anomalies.

None of the images on the pages that follow are cropped or altered in any way to change or conceal any part or portion of them. Are pictures worth 1000 words? Again, don't forget ... this happened to 2 buildings in less then 10 seconds each and some anomalies had to occur in just a few milliseconds.

please take the time to carefully examine the images in this eMagazine using the zoom feature

Many of them, but not all of them, as I've stated repeatedly, are high quality images that can be zoomed several times without distortion. I see no evidence of incendiary devices or conventional explosives.

What I do see is lacerated, slashed, ripped and torn metal; rows of 1" and larger bolts sheared from their holes, structural steel two and a half inches thick shredded, ripped and bent like rubber but no evidence of the thermal output of an energetic compound. However, if a nuclear device heated to 10 million degrees for a nano-second in a radius of 10 or 20 feet, with a secondary radius of another 50-100 feet of 300,000 degrees and a third radius at 50-200 feet of 3,000 degrees and then rapid heat deceleration from there – remember, the bomb lit to 10 millions of degrees for just a nano-second or so – then every anomaly associated with 911 is explained from the horseshoe shaped I-beams to the vaporized people and the oddly burnt cars. No flames, nothing visible, no fire. Just the unseen yet incredibly enormous heat of highly charged, infinitesimally small reacting neutrons, invisible, but sizzling in the clouds as they passed.

Metals attract neutrons. Cars a good distance from demolition and on a straight unhindered path would burn, especially the heavier metal parts but paper floating everywhere wouldn't be affected. The 911 site, from Ground Zero outwards is littered with paper and none of it has burn marks on it. The buildings themselves would look like a fountain of destruction, as they did, but a fountain growing smaller and smaller, diminishing in height but not horror, again as they did. With a constant upward force spewing dust a mile high and ejecting multi-ton structural steel components at 50-60mph imbedding them into adjacent buildings on neighboring blocks, the force of energy, for less then ten seconds was unimaginable. The force during each one of those single ten seconds was massive. Less than 10 seconds.

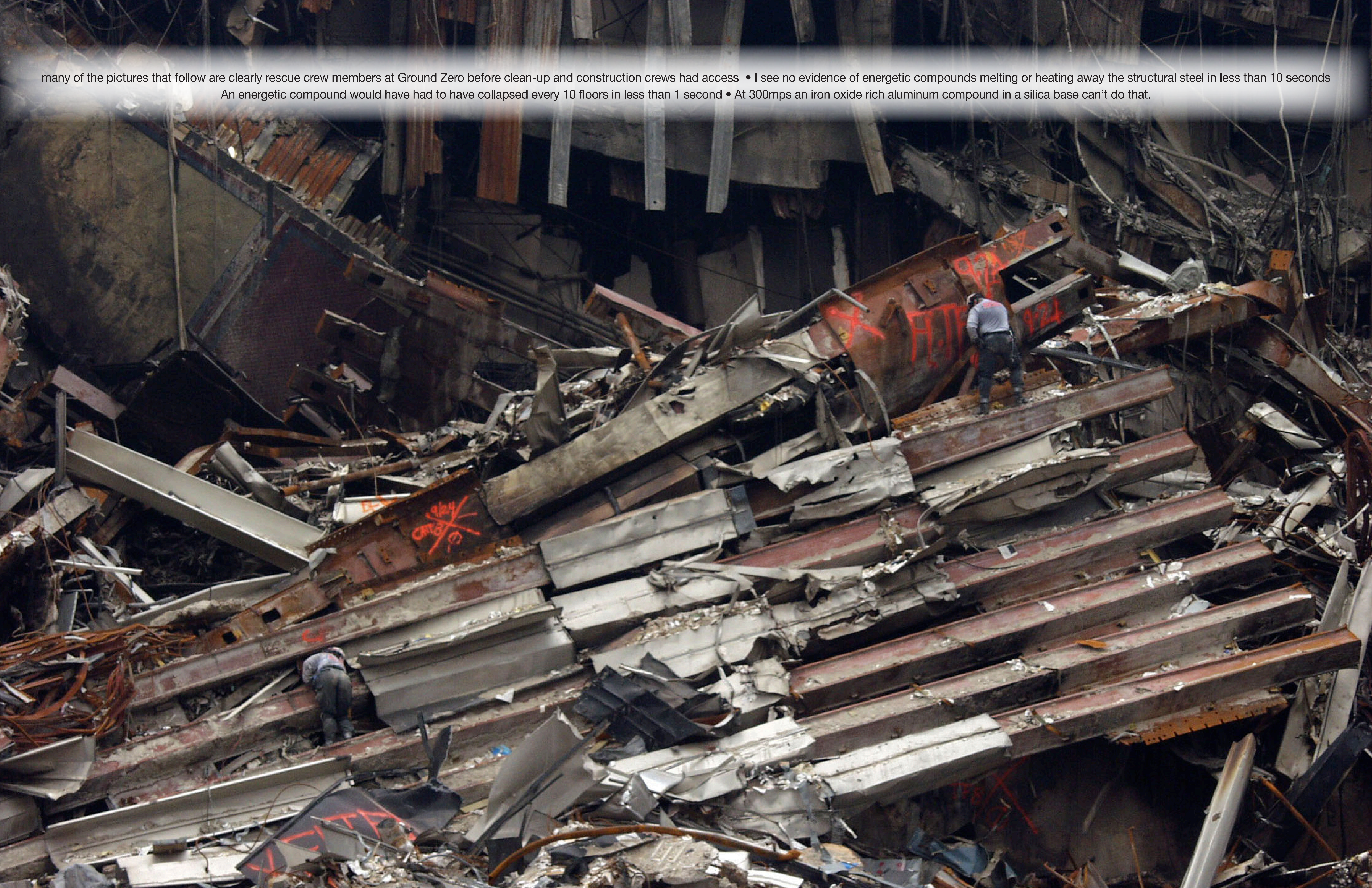
Then it was done.

Dr. Stephen Jones writes:

"***Explosives such as RDX, or HMX, or superthermites***, when pre-positioned by a small team of operatives, ***would suffice to cut the supports at key points such that these tall buildings would completely collapse with little damage to surrounding buildings.*** *Radio-initiated firing of the charges is implicated, perhaps using superthermite matches. Using computer-controlled radio signals, it would be an easy matter to begin the explosive demolition near the point of entry of the planes in the Towers (to make it appear that the planes somehow initiated the collapse.) In this scenario, linear cutter-charges would have been placed at numerous points in the building, mostly on the critical core columns, since one would not know beforehand exactly where the planes would enter*."

Yet by Jones' own admission (*Harrit, 2010*) his iron oxide rich aluminum nano-compound in a silica substrate found at Ground Zero and studied extensively in the Bentham Open Chemical Physics Journal [http://www.benthamscience.com/open/tocpj/articles/V002/7TOCPJ.htm] has a velocity of 300 meters per second (*mps*). He classifies his nano-compound with RDX and HMX which have velocities closer to 9,000mps. Is this foolishness? Bad science? Three-hundred (*300*) meters per second versus Nine-thousand (*9,000*) meters per second? RDX and HMX and even TNT (*almost 9,200mps*) generate 30 times the explosive or total thermal energy or power than the nano-energetic compound Jones claims to have yet he compares them as being similar in explosive power? His compound is classified as an incendiary. The 911 truth movement has never recovered from this colossal, ignorant blunder. At 300mps his nano-compound would require "*29,000 metric tons*" (Harrit, 2011) as a low or minimum with a maximum of 144,000 metric tons. This theory falls on its face more than once for a number of reasons. Energetic compounds alone simply can't do what we saw. Study the dust.

many of the pictures that follow are clearly rescue crew members at Ground Zero before clean-up and construction crews had access • I see no evidence of energetic compounds melting or heating away the structural steel in less than 10 seconds
An energetic compound would have had to have collapsed every 10 floors in less than 1 second • At 300mps an iron oxide rich aluminum compound in a silica base can't do that.



Bolts ripped out of their holes ...

A Lot
Of Evidence
Of Torn & Ripped
Structural Steel And Dust.
A Lot Of Dust.
Above, left, 18 bolts, big as a fist
ripped apart,
the steel torn
to shreds.

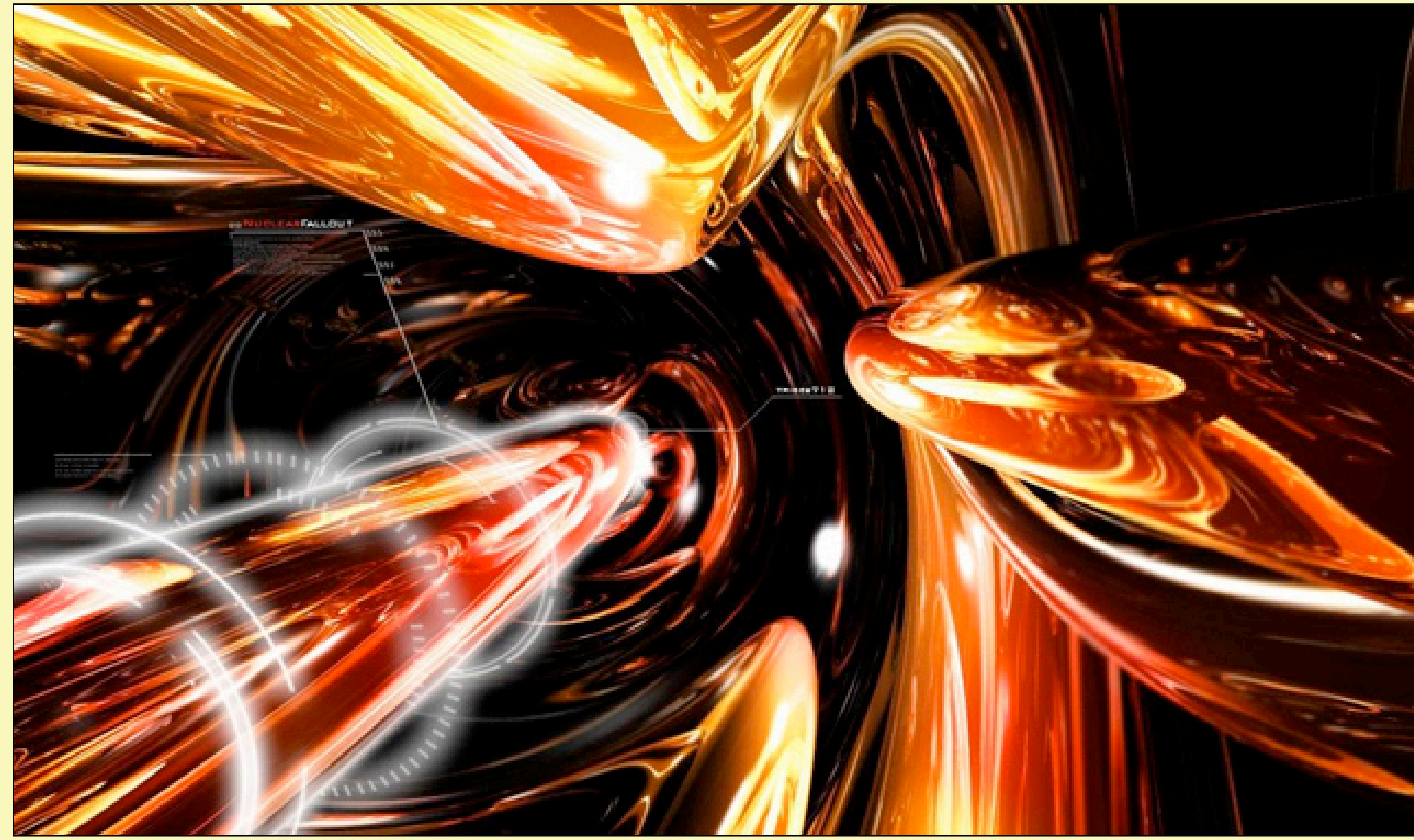

FLTF1
X FLTF1
CATF-7
X FLTF1

The steel structural beams are still
covered with the fine powdered dust
seen everywhere else. Is the insulation
blown off of the larger beams?

What kind of unseen force would blow the
asbestos coating right off the two and a half
inch steel beams it had been applied to?

THE CIRCLES

There are lot's of circles on the images. The circles (*zoom in on the circles*) on the five previous pages (*and on other pages*) show box columns demolished in the rubble. All of the box columns are broken, disconnected or detached at their joints, where they were originally connected via a supporting system of structural steel, gusset plates, to fasten the columns together. Welded gusset plates and stand-off plates with bolts ripped from the floor truss supports are what we see. No signs of energetic compounds.



At these breaks there is no evidence, none at all, of the concomitant melted metal and burning that would be associated with an energetic compound of any kind, regardless of its velocity or maximum temperature.

The tubular steel structure of the Twin Towers, the box columns, were always under tremendous stress. They were supporting, just in the construction of the towers, approximately 200,000 tons of building material per tower. With 1000s of people, fixtures, carpet, toilets, etc., they were probably supporting well over 200,000 tons. The steel structure was always under stress. Winds included.

The heat from a nuclear demolition, a very small series of deuterium-tritium fusion devices for just a millisecond, would have provided the necessary heat to cause total building failure and collapse, WITHOUT burning or melting the metal in most cases.

It would account for 1 inch steel bolts and larger being torn from their joints and it would account for the rips and tears we see in the structural steel, without burned and melted steel or tears in the longer radii to accompany those rips and tears. A demolition using very small micro-nuclear devices would account for the fact that nowhere in any of the images of the steel, and the images in this eMagazine were taken before demolition and during rescue operations, are showing signs concomitant with energetic compounds melting the steel.

There are images though, in this eMagazine, that show the signs of the heat of nuclear demolition; the heat of fast, invisible neutrons that are attracted to metal. Fast neutrons attracted to cars, structural steel and not paper or paper products, passing right through them For just a millisecond or less.. 911 was a nuclear event and *THAT* is the secret that no one wants us to know. Yet now we know. Some of us ...

At the top center of the image at right on the darker building in the background I see an example of high heat and a scorching effect; more than just a fire but a massive massive raging inferno. At the central column sticking up through the debris at the bottom center of the same image, protruding up behind the two Rescue Workers, I see evidence of scorching heat also and a small outward bulge at the top, long side, and a wider, longer inward bulge at the lower, long side. These structural steel components were stressed to their maximum temperatures for days, or they were subjected to massive heat for milliseconds. Millions of degrees. But I don't see evidence of 1, 2 or 3 seconds of 4500 degrees from Dr. Jones' thermite. It would have to be accomplished at 1 second per ten floors. This picture (☞) can be zoomed and there's a larger one on a previous page.

Above, bolts are ripped from their anchor holes but there seems to be no sign of melted metal as one would expect to see with a nano- energetic compound burning in excess of 4500+ degrees for less than 10 seconds. None of the metal I've seen in pre-clean-up rescue images has signs of melting, burning or detonating in a fiery explosion. The huge I-beams to the right look as though they were cut or failed at seams.

SHOP

I don't see evidence of 10 seconds, or even several seconds of steel columns burning, melting from a 1-2 second burn of an energetic compound. I don't see the evidence, for example in the two and a half inch thick beam below. With two sides this I-beam is 5 inches of structural steel (2.5 inches per side), bent like a horseshoe in less than 10 seconds. Without tears in the longer radii, and there aren't any, heat would have had to have reached many thousands of degrees for just milliseconds and the energetic compound found by Dr. Stephen Jones, with a velocity of 300mps and a maximum peer reviewed velocity for any iron oxide rich aluminum nano-compound in a silica substrate at 895mps maximum, simply won't accomplish this and adequately account for dozens of additional Ground Zero Twin Towers anomalies.

I see the result of 10 million degrees for 50 feet and 300,000 for another 100 and 3,000 for another hundred and much less thereafter, all in less than a millisecond or maybe two milliseconds. Rapid cooling, almost seemingly faster then the heat itself. Heat from radiation, unseen, at those temperatures for just milliseconds and then rapid cooling or return to normal temperatures isn't a normal experience for those on the very edges of survivability for events like this as the following quotes indicate:

For those running away whose testimony I've listened to and recorded, they experienced "*heat on the backs of my legs, my arms and my head, as though I were on fire*." One woman turned around for just a moment to "*see people vaporized where they stood*." Another saw "*cars burst into flames spontaneously*" as she was running away. A nuclear event, a neutron device based on deuterium, tritium and perhaps other exotic metals (*or not-so-exotic since lead, copper, silver and others are used too*) the size of an apple, explains these and many more anomalies.

With a small enough device many people within 500 feet might not even feel the effects of neutron bombardment. Others would breathe the dust unknowingly for 5 or 6 days in hectic, disorganized relief efforts where fireman couldn't talk to policeman because their radios were on different frequencies. They were unable to communicate or hear each others announcements. True enough.

If you liked Katrina then this rescue effort was the Marx Brothers, Laurel and Hardy and the Keystone Kops all rolled into one even though that won't be admitted in the mainstream media.

It was a "Get Wall Street Open Effort" from the first second, well before the dust even settled and even though it didn't settle for months, the politicians and media pundits were there telling us to go to the mall and shop, buy plastic stuff at WalMart or wherever you care to spend your dough. The message was clear.

Shop.

SHOP

PART SIX CONCLUSIONS

1. It's now time for you to draw some of your own conclusions. Will you use this eMagazine and the many links to study these issues further?

PART SEVEN
FRAGMENTS

*Nano energetic explosives require an added explosive element otherwise a nano-energetic compound is an incendiary albeit a very rapidly burning incendiary. If RDX, TNT or any other type of explosive were added to a nano-energetic compound it would then be explosive. Without an added explosive element it is considered an incendiary. An exception is when it's highly compressed in pellet form.

ENERGETIC NANO-COMPOUNDS
METASTABLE INTERMOLECULAR COMPOPUNDS (MIC)
SOL GEL BASED AND SILICA BASED
NANO SCALE INCENDIARIES & NANO-EXPLOSIVES*

The complexities of a nuclear explosion of a particular type and especially those of a radiological device (RDD) are difficult to explain and won't be discussed in depth here. Salted versions of both fission and fusion weapons can be made by a change in the materials used in their construction.

There are dozens of different types of nuclear weapons based on differing elements such as deuterium, plutonium, tritium, uranium, zinc, lead, silver, gold and other metals. They all have widely varying and substantially different radiation paths and zones of destruction.

There are neutron, hydrogen, salted gold, salted silver, and other salted bombs of proposed types such as the cobalt bomb, which uses the radioactive isotope cobalt-60 (^{60}Co). Other non-fissionable isotopes can be used, including gold-198 (^{198}Au), tantalum-182 (^{182}Ta) and zinc-65 (^{65}Zn). There are others.

Certain elements of these explosive devices are ones we can become familiar with if we're not already. There's enough credible material to make sense of a great deal of these little known technologies where science, physics and some of the once theoretical become proven and verifiable facts. And this includes nanotechnology and everything associated with it in the field of nuclear explosive mechanics (physics). I've examined 100s of pictures (some in the pages that follow) of girders, steel plates, flanges as well as piles of utter destruction and none show anything resembling signs of a thermite or nano-energetic explosive burn across the steel structural components. Not that I've seen.


F.D.N.Y.

NIST IMAGES


Splice in the 98th floor
Fractured end near the 100th floor level


AA Flt.#11 Window/Fuselage Section


Exit Vesey Street, West Broadway
New Jersey Ferries
Exit
Exit
Service exit

DUST

THE ARGUMENT FOR THERMITE OR ENERGETIC NANO-COMPOUNDS

As a secondary mechanism for destruction wholly unnecessary to the destruction itself energetic compounds may have played a part in destroying the buildings by scaling the parts into easily maneuverable and disposable sizes. The thermal capacity of Dr. Jones, et al., energetic compound at a velocity of 300mps and with an iron oxide rich aluminum structure in a silica sol gel base with a maximum of 895mps the compound alone could not calcine 100s of 1000s of tons of concrete, create the micron sized aerosol particles and maintain temperatures in excess of 2500 degrees at Ground Zero "*boiling soil and glass*" as Dr. Thomas Cahill from the UC Davis Delta Group states. Particles, specifically aerosols, were being "*regenerated*" according to Cahill and the atmospheric dust samples were found coated with soot proving recent generation in the Ground Zero fires raging far beyond human control, even with Pyrocool® and previously heavy rains.

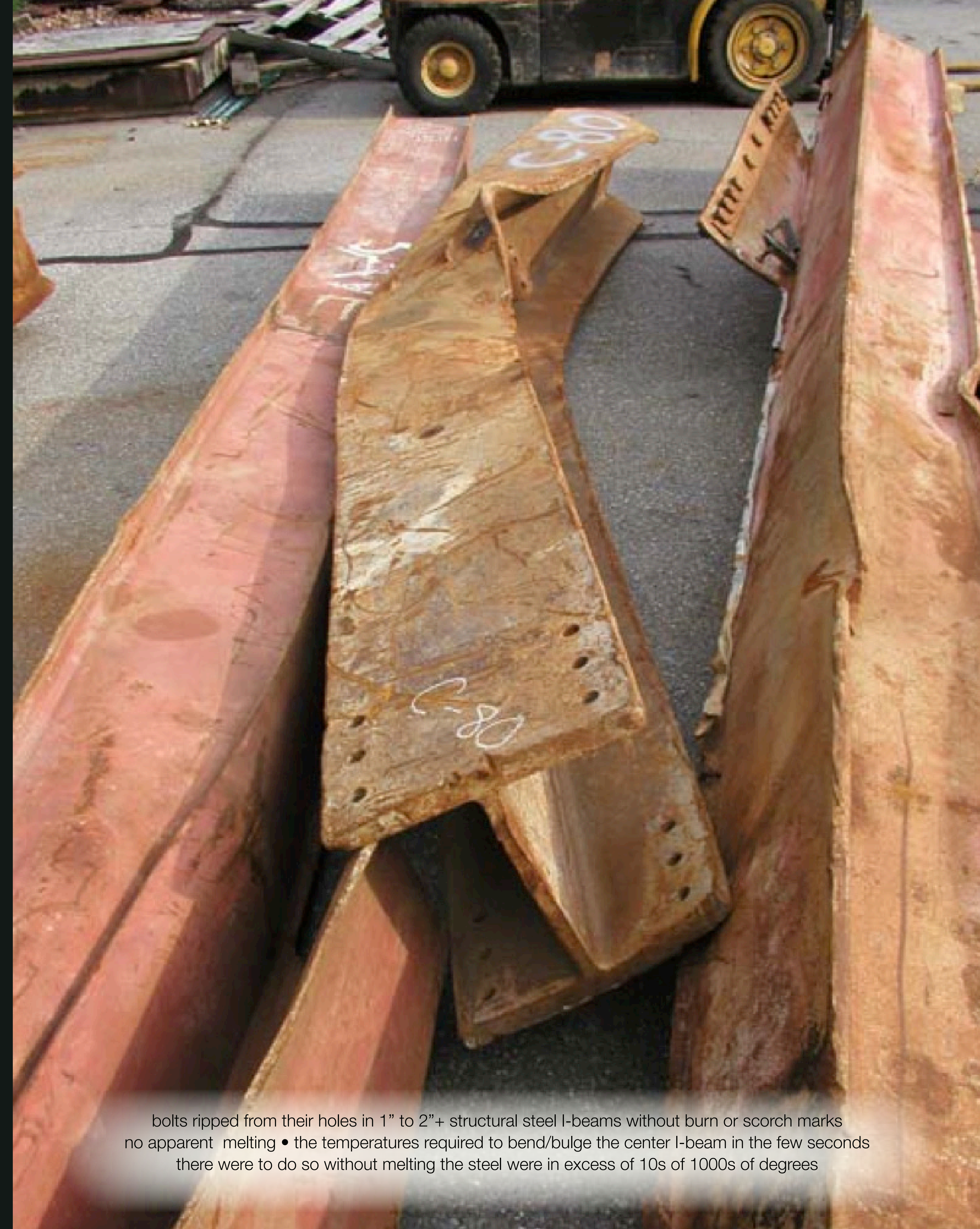
An argument against energetic compounds includes the following internet statement: "*Those marks in the last photo (center left), which is just a close up of the first (far left), indicate an oxy/acetylene torch cut. All of which, I have experience with. From being ex Army to having worked in mining.*" Is this true? Seems so to me but I have no experience in welding on this level.

So we have varying interpretations of the ability of the energetic compound in Jones' possession to cause the damage seen and we have seriously and crucial questions as to the total thermal capacity needed to calcine so many tons of concrete. We also have strong anecdotal evidence in the many cancers and we have scientific evidence in the form of high levels of tritium and uranium.

Unexplained high levels. Levels that cannot be explained by gun sights, watches and 34-68 Boeing Exit and Emergency signs.

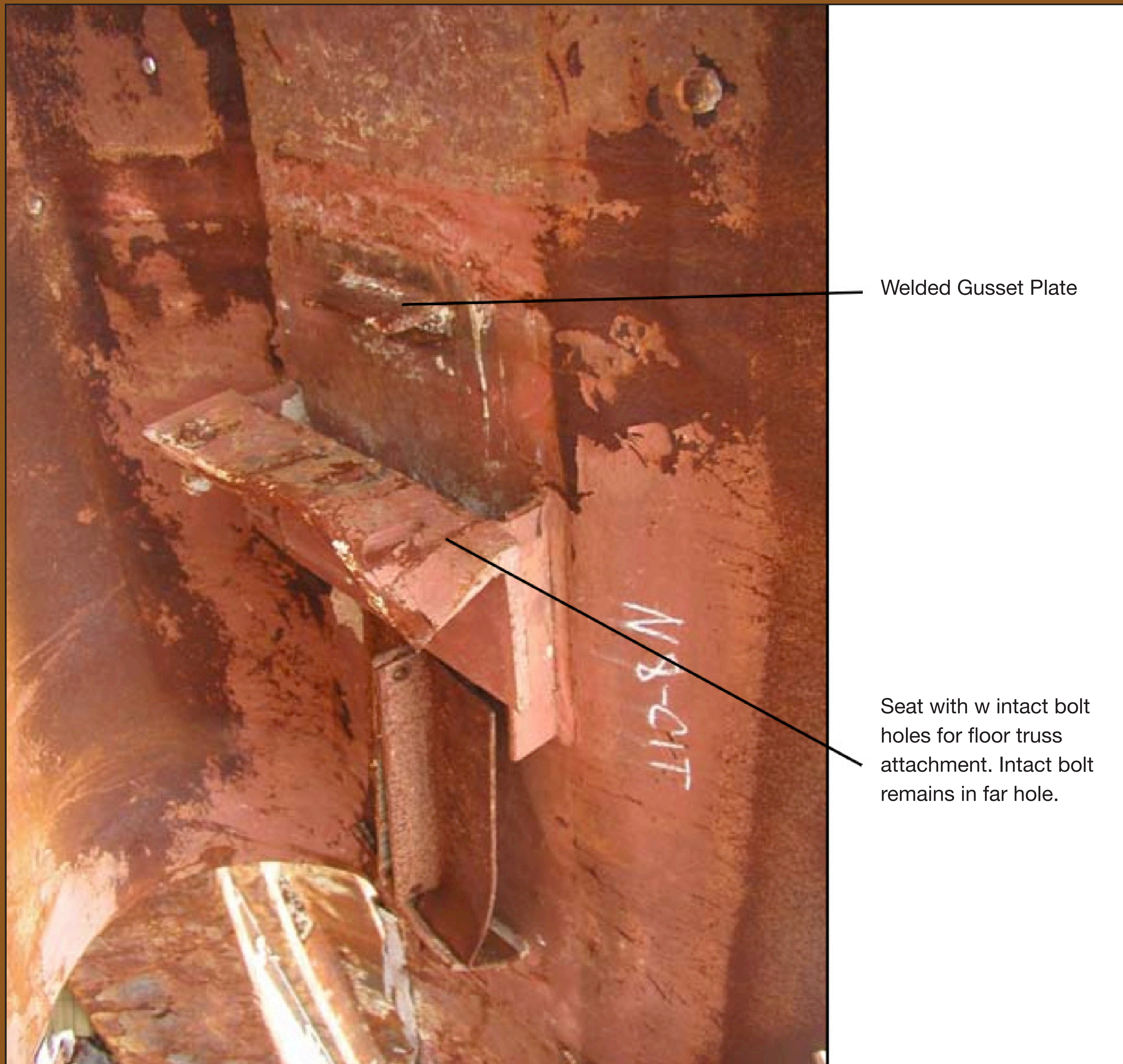
Totally unexplained high levels of uranium as well. And Potassium. And Sodium. And Zinc.

NO BURNS



bolts ripped from their holes in 1” to 2”+ structural steel I-beams without burn or scorch marks
no apparent melting • the temperatures required to bend/bulge the center I-beam in the few seconds there were to do so without melting the steel were in excess of 10s of 1000s of degrees

NO BURNS



Bolts ripped from their floor truss holes in structural steel without burn or scorch marks. No melted metals visible.

Fuselage fragment

A fragment of a wing fuel tank found at the World Trade Center site shows a thick compound around the nuts, used to prevent fuel leaks.

NO BURNS

Bolts ripped from their seated stand off plates in structural steel without burn or scorch marks. No melted metals visible. At the far right we see ripped and torn structural steel without burn or scorch marks.

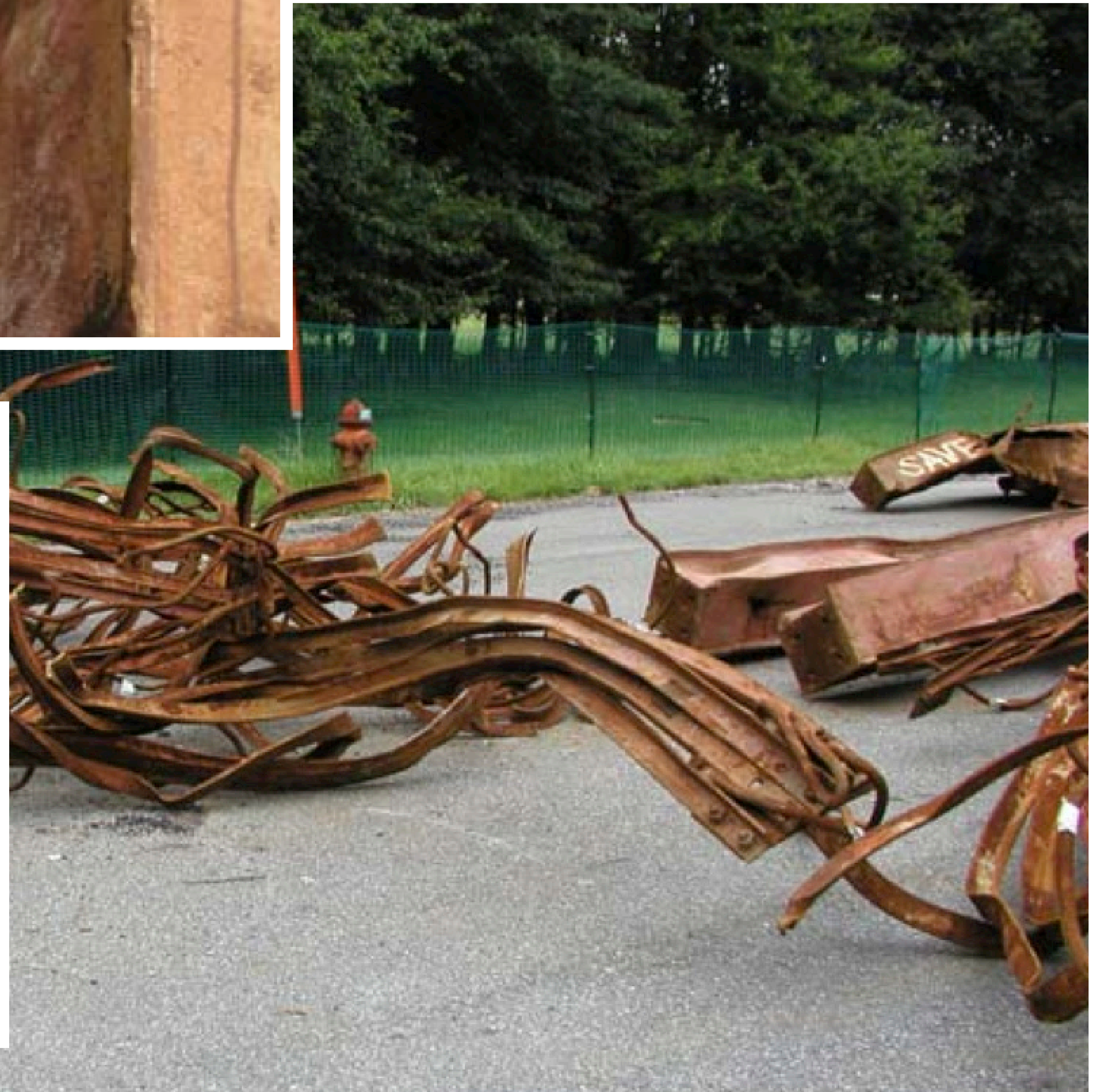
Fragment of fuselage skin found at World Trade Center site.

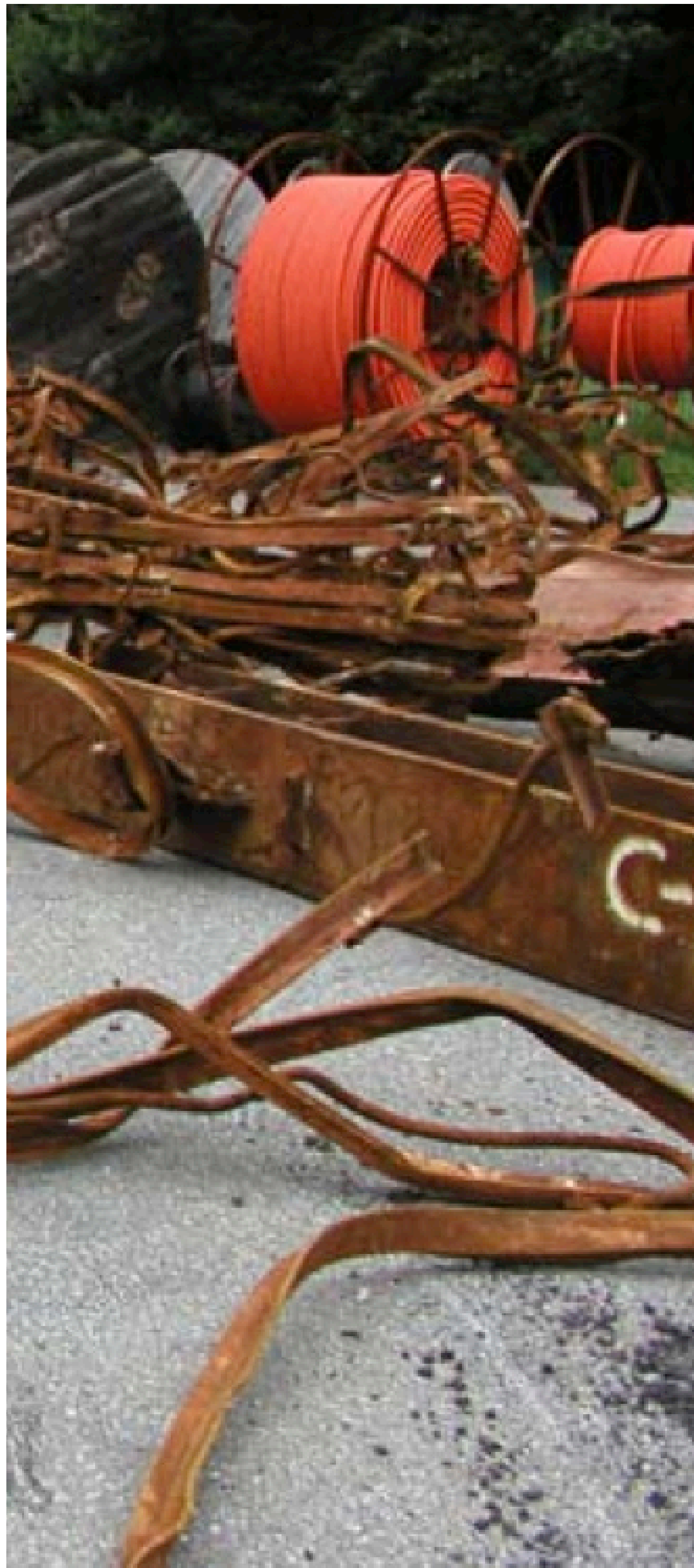
Seat belt from a crew member's jump seat on American Airlines Flight 11, the plane that was crashed into the north tower of the World Trade Center.

NO BURNS OR MELTED METAL

NO BURNS

These original images are available by request using a Facebook private message. No parts or portions of the images in this eMagazine are concealing anything that might be considered showing evidence of energetic compound reaction in the 300mps to 895mps range with temperatures in the 2500 - 4500+ degree range for the less than ten second period available per building.





the very fine dust covered everything uniformly and it was everywhere; in ducts, in clothes, in carpet, in cracks and crevices we didn’t know and still don’t know we had ...
you’ll see from the image on the next page that the dust was inches thick and finer than baby powder outside - micron sized


PARKER
SAFETY
Nano Patrol
MICRONS
John R. Microns
~ FIRST RESPONDER ~
September 11th, 2001
May 18th, 1970 - September 11, 2001

IMPALED BUILDINGS

There were more impaled buildings than the media would have you believe and this book has examples of a dozen or more. Look carefully and you'll see them. Some, but not all of the images can be zoomed several times. The circled area in this image is a 2.5 inch thick structural steel box beam, bent, torn and shredded without burn marks. And hoisted 100s of feet with extraordinary force.

This building wasn't just impaled. At the corner of the building just about an inch or two above the bottom of the image is a structural steel plate with 12 bolts showing and it's ripped apart, the bolts sheared. On close examination both the building and the structure that hit it are severely damaged and free of any visible burns. The velocity of the structural steel from the World Trade Center was enormous, estimated at between 50 and 60 miles per hour.

The estimated velocity of the energetic compound examined by Dr. Jones, even if it had a velocity of 895 meters per second, though his is estimated at 300mps, would still have far too little velocity to propel hundreds of tons of structural steel at speeds estimated to be at least 50-60 miles per hour, into buildings a block or more away from the towers.

I'm not going to say energetic compounds weren't used but if they were used they were inconsequential to the demolition of the Twin Towers; not an essential part at all.

There was a tremendous, incredible and massive amount of dust spread across lower Manhattan. As it settled as it would and as it did, it told an elaborately intricate human story. Examine the dust.

NUCLEAR FEET?

NUCLEAR ODER EATERS™

DESTROY ODOR ON CONTACT

Oder Eaters meet the strictest USDA and IAEA standards for nuclear radiation fallout odor and will absorb all fallout odors to include alpha, beta, gamma fission radiation and even rare neutron odors from fusion reactions.

All radiation related odors are always guaranteed not to be detectable by the normal sense of smell and all standard Geiger Counters or your money will be fully refunded with your dated local store receipt.

Guaranteed to be effective against tritium and deuterium fallout.

Guaranteed!

EXPLOSIVE ERUPTION SEQUENCE – WHAT DO THESE PICTURES ACTUALLY SHOW?

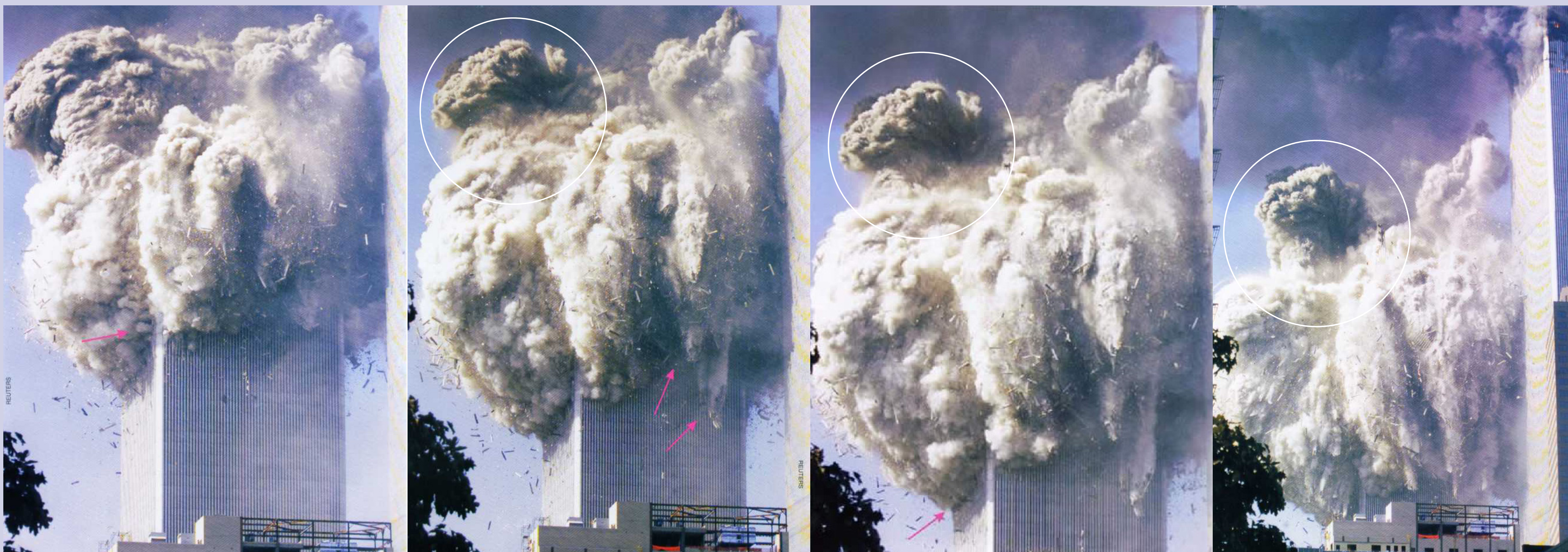
The large cloud developing at the top left in the far left picture exhibits tremendous explosive force and this is apparent as we look across the four images to the last image on the far right. This portion of the cloud is exploding upward with tremendous energy and power.

Each image, as we look from left to right at the darker cloud in the upper center *(as we move left to right)*, shows an extraordinary upward thermal force. The fourth picture from the left or the last one on the right shows incredible upward energy.

The thermite found by Dr. Stephen Jones and confirmed by Dr. Neils Harrit to have a velocity of 300 meters per second (mps) can't do what we see here and that's just simple science.

As an example, RDX has an approximate 8,500 meters per second (mps) velocity as compared to Dr. Jones' energetic compound with an estimated velocity of 300mps and a maximum for iron oxide rich and aluminum energetic compounds in a silica substrate of 895 meters per second based on peer reviewed data specifically on iron oxide and aluminum nano-compounds. Energetic compounds can't hoist building structure components that weigh 100s of tons and eject them into adjacent buildings. An experienced controlled demolition expert would know this.

What's happening here is a well known but little understood force we've seen before. We've only seen it on very enormous scales so to visualize it on such a minimal scale is difficult but it seems to me we should all be thinking about apples. All 3 circled areas appear as upward explosive forces.



PART SEVEN AND FINAL CONCLUSIONS

1. This text within the pages of this eMagazine and the images that accompany it speak loudly and clearly for themselves; loudly and clearly. The text supports the conclusions. 911 was a nuclear event.

END NOTES

911 METEORS AND OTHER RARELY SEEN IMAGES


BRER - FOUR
Transportation

The bolts (left) are holding up well but where's the front end of this truck?

This steel is ripped by force,
not cut with energetic compounds.

THE HEAT

GROUND ZERO HEATS UP

This all happened to each building in less than ten seconds. With an energetic compound the time to demolish every ten floors is less than one second. With an ignition and rapid burn rate in the millisecond range this is possible but we'd see melted steel at all the box column ends and we'd see cracks and stress marks on all of the heavily bent box columns. The total heat generated would not have been enough, for a long enough period of time, to bend the box columns into the u-shapes seen. Most importantly, Dr. Jones' compound has a velocity estimated by Dr. Harrit as 300 meters per second while RDX, TNT and HMX are in the 8,500 to 9,000mps range. The thermite 'discovered' by Dr. Jones simply doesn't have the velocity to demolish the buildings as we saw them demolished.

We also wouldn't see anomalous increases in uranium, vanadium, zinc, sodium, potassium, thorium, tritium and other elements intimately related to a nuclear event.

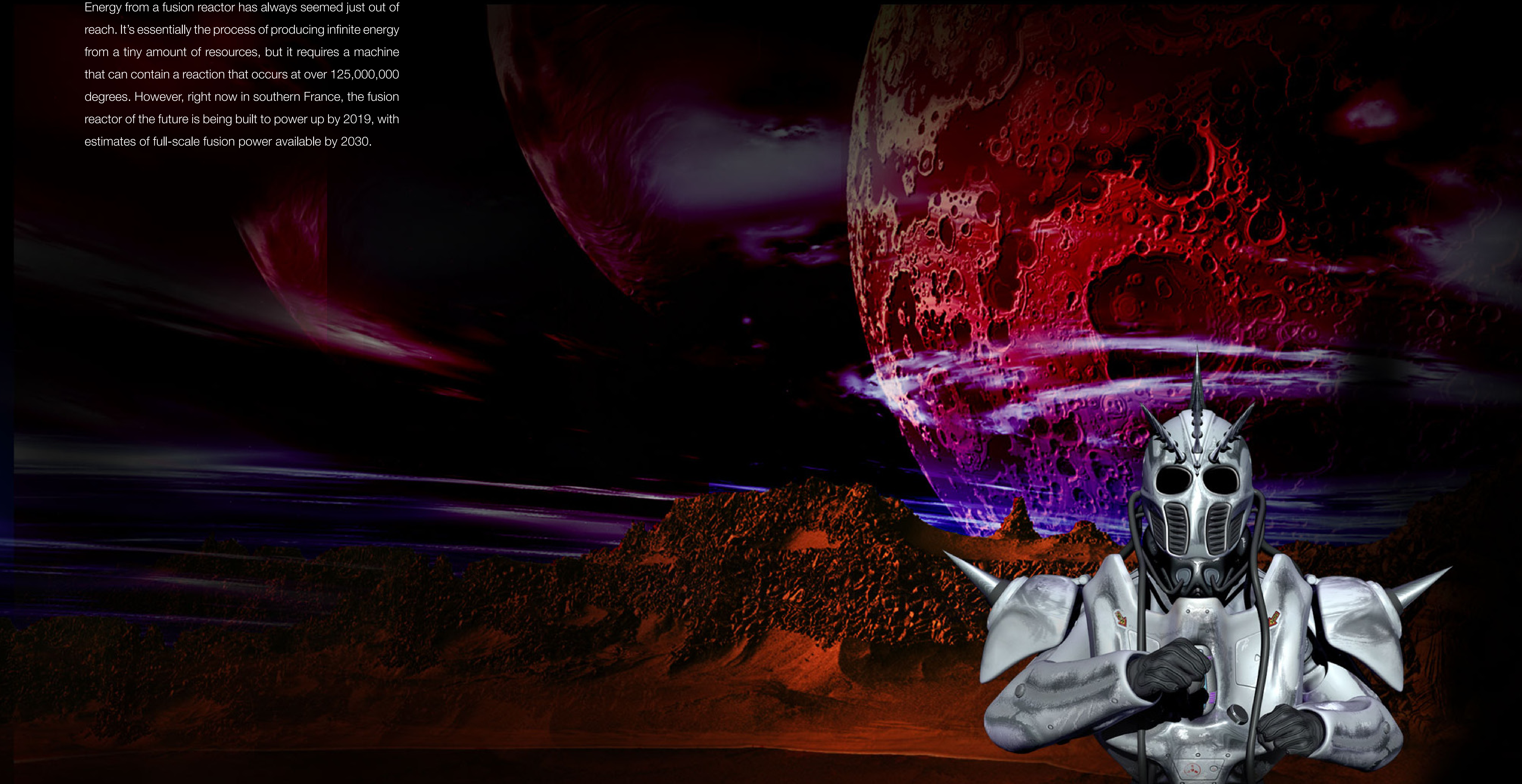
We don't see burns or melted metal on the girders. We see absolutely no evidence of burned or melted steel. In the first pictures of Ground Zero taken before any clean-up had begun while First Responders were still searching with their trusted now deceased dogs for still living human bodies; we see no evidence of explosives or incendiaries.

We do see the results of as much as 10,000,000 degrees or more for just a millisecond or so. This would cause floor truss bolts about an inch in diameter, or more, to be 'missing in action' with no apparent explosive or nano-energetic compound signs on their flanges. The bolt holes are ripped open, the bolts sheared off. No melting or apparent explosive residue. But 10 million degrees for 1 or 2 milliseconds or so would have caused total failure with all the parts remaining pretty much intact. Except of course for those U-shaped structural steel box column girders. They were heated to millions of degrees for a millisecond or so and the weight they were supporting caused immediate and total building failure without a crack, a rip, a tear or a mark on the long or short bent radii. Only a nuclear demolition makes sense. An energetic compound simply can't heat up quickly enough, for a long enough period of time to cause a 2.5 inch structural steel box column to bend like a horseshoe without leaving forensic signs. The paid acceleration and deceleration of heat in a nuclear explosion, from 0 to 10 million degrees in milliseconds makes sense here for building failure. Just as fast as the heat was generated it dissipates. For illustrative purposes only and not using exact figures at all, if the nuclear explosive device were small enough the point from Ground Zero to 25 feet out might experience heat in excess of 10 million degrees. From 25 feet to 75 feet the temperatures might be in the 300,000 degree range. From 75 feet to 125 feet the temperatures could reduce to approximately 3,000 degrees and then outside the 125 foot mark and up to 175 feet the temperatures would reach just 300 degrees. All for just a millisecond. People vaporized. Others just steps further away felt the heat and witnessed the vaporizations.

Welded joints would fail. Concrete would return to it's primary constituents being calcined to micron-sized dust, cars would spontaneously burst into flames, people would vaporize if they were within certain zones or radii of the explosion. The concrete would turn to dust along with everything else. No computers, no desks, no chairs were found. But far more important is that no toilets or urinals were found. Porcelain and ceramics should have been found regardless of what type of building demolition this was. Conventional explosives, jet fuel, energetic compounds, energetic nano compounds and energetic explosive nano compounds would have all left toilets and urinals, or at least parts, pieces or chips of the porcelain and/or ceramics. None were found. What happened to 1000s of toilets, urinals, sinks and other fixtures that should have shown up, at least in parts and pieces? 911 was nuclear, that's what happened ...

Nuclear Nano-Tech Is Not Safe For Children And All Living Creatures

Energy from a fusion reactor has always seemed just out of reach. It's essentially the process of producing infinite energy from a tiny amount of resources, but it requires a machine that can contain a reaction that occurs at over 125,000,000 degrees. However, right now in southern France, the fusion reactor of the future is being built to power up by 2019, with estimates of full-scale fusion power available by 2030.



STOP NUCLEAR NANO TECH

THE GREAT DIVIDE

The 911 truth movement is forever divided, disrupted and rendered useless by a system specifically designed to suppress the truth and propagate systemic frauds.

There are planers, no planers, hijackers, no hijackers, passengers, no passengers, thermite, nuclear and space beam weapons enthusiasts who believe their chosen dogma no less then an enthusiastic man of the cloth. Science is complicated. Beliefs are simple but generally lacking science.

(BNN - May 29, 2007 - Duluth, MN) - Cindy Sheehan, anti-war mom of a soldier killed in Iraq "*for nothing*", today left the anti-war movement.

Once a proud and courageous symbol of the fight to end the Iraq war, Sheehan was the Left's symbol of courage, moral authority, and the antiwar movement's Joan of Arc. But no more. Cindy Sheehan has been shunned by her comrades on the Left. She came to realize that the anti-war left had been using her all along - and committed the mortal sin of saying so. Cindy Sheehan in her personal grief and torment was but a "useful idiot" to the Left, useful for the anti-war movement's political objectives.

"Yesterday she violated Rule One of nutroots politics as articulated by the Chairman himself: she undermined the Democratic Party. Twenty-four abusive hours later, on a day dedicated to honor people like her son, Mother Sheehan's decided it's time to pitch one last attention-getting fit and then take her absolute moral authority ball and go home," says Allahpundit

Many saw it coming.

"*When a mother looses a son, preeminent in the psychology of grief is the emotion of anger and rage. This is the phenomenon that we are currently experiencing with Cindy Sheehan, a woman whose son died in Iraq, a mother in crisis being manipulated by political forces with little regard concerning her emotional health.*" This according to Robert R. Butterworth, Ph.D. a psychologist that specializes in trauma. Dr. Butterworth feels that Ms. Sheehan is delaying the grieving process concerning her son and will be destitute when the media move on to the next story and she is forgotten and left alone. Butterworth feels that in is unconscionable for political forces, regardless of their positions to take advantage of mothers who are grieving for their sons both for and against the Iraq war.

Jim Fetzer, once the darling of the 9/11 Truth Movement, saw it coming too. From his redoubt in Duluth, MN, Fetzer told reporters, "*I feel Cindy's pain. I too was shunned, tossed aside by the 9/11 Truth Movement like so much raw pork.*" Fetzer has been mercilessly attacked by 9/11 Truthers for looking at alternative theories about the 9/11 attacks. Fetzer is currently working with co-conspirator Dr. Judy Wood on the likelihood that the World Trade Center towers were destroyed by Star Wars Beam Weapons.

Ever since 9/11 Truther and jingoist Jon Gold attacked Fetzer as "*a real porke*r", the attacks have increased. "*The reality is that this movement is tired of you. You do not speak anymore for this movement...,*" Jon Gold wrote to Dr. Fetzer.

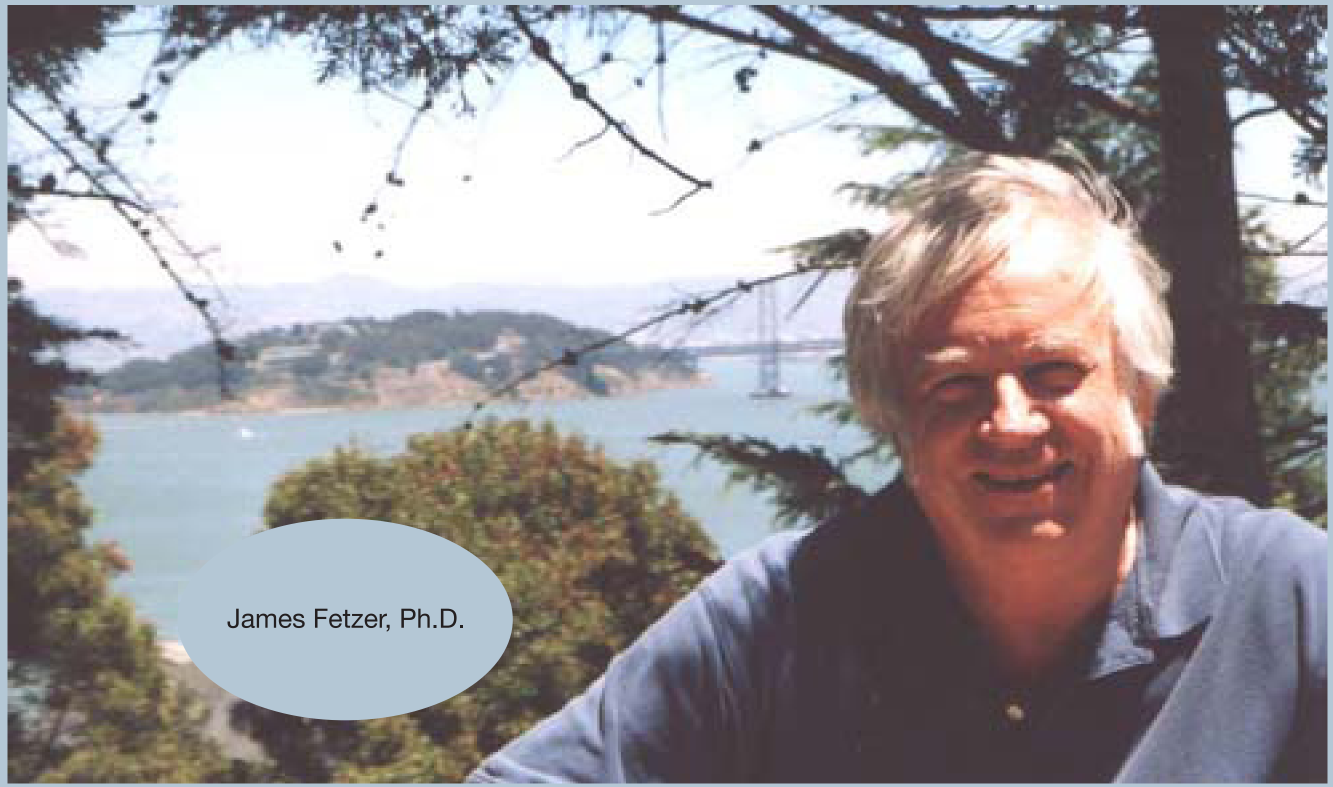
Fetzer says that "media whores Dylan Avery, Jason Bermas, and Korey Rowe are next to be discarded from the 9/11 Truth Movement like plucked chickens."

"*These kids are intoxicated with themselves, with celebrities and with video games. They are clueless about the real world and believe the official 911 Truth Movement story is the holy grail and their ticket to God-knows-where.*"

"*And they lip-sync on 'Loose Change' like Milli Vanilli.*"

Personally I'm with Jim on most of these issues. While I don't believe Dr. Woods is using a logical scientific methodology that can also be proven one way or the other I do believe in investigating every aspect of the events surrounding 911 bar none.

While my focus has been specifically on the dust for the last several years I also spent several more years looking carefully and thoroughly at the global financial forensics. These are two complex, intricately detailed, knotty, thorny and convoluted areas of widely separate study with very intimate and unusual connections and I know of few people that have been willing to tackle either.



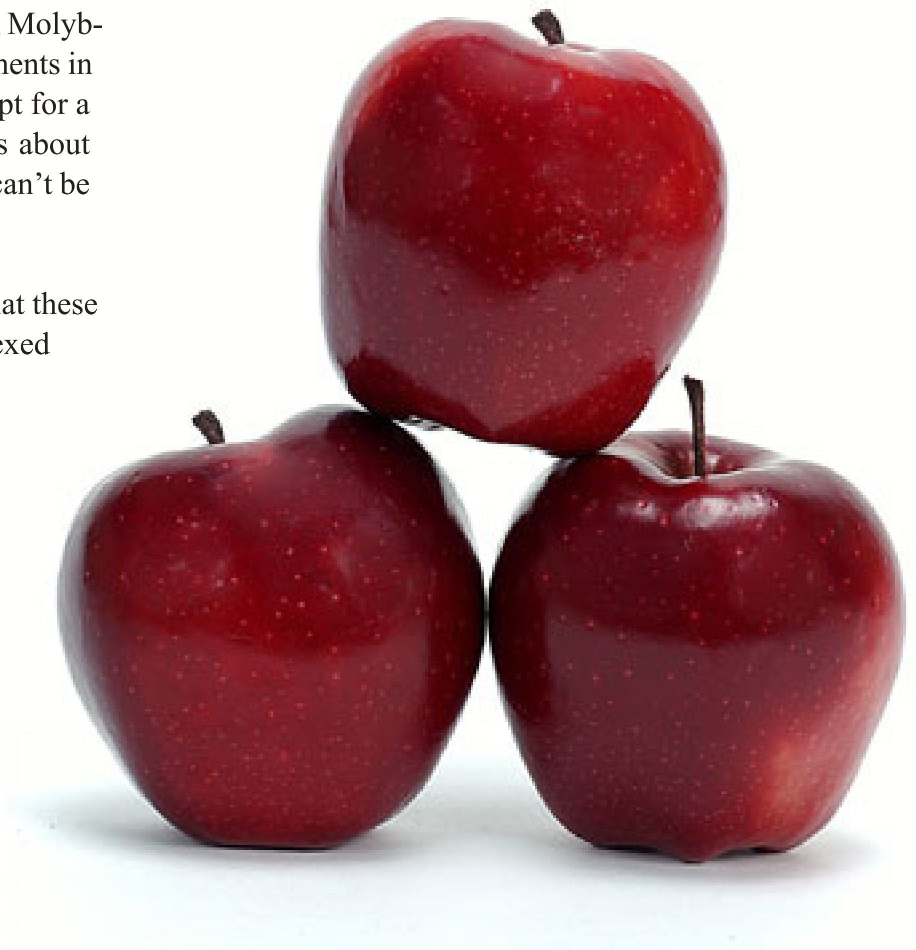
James Fetzer, Ph.D.

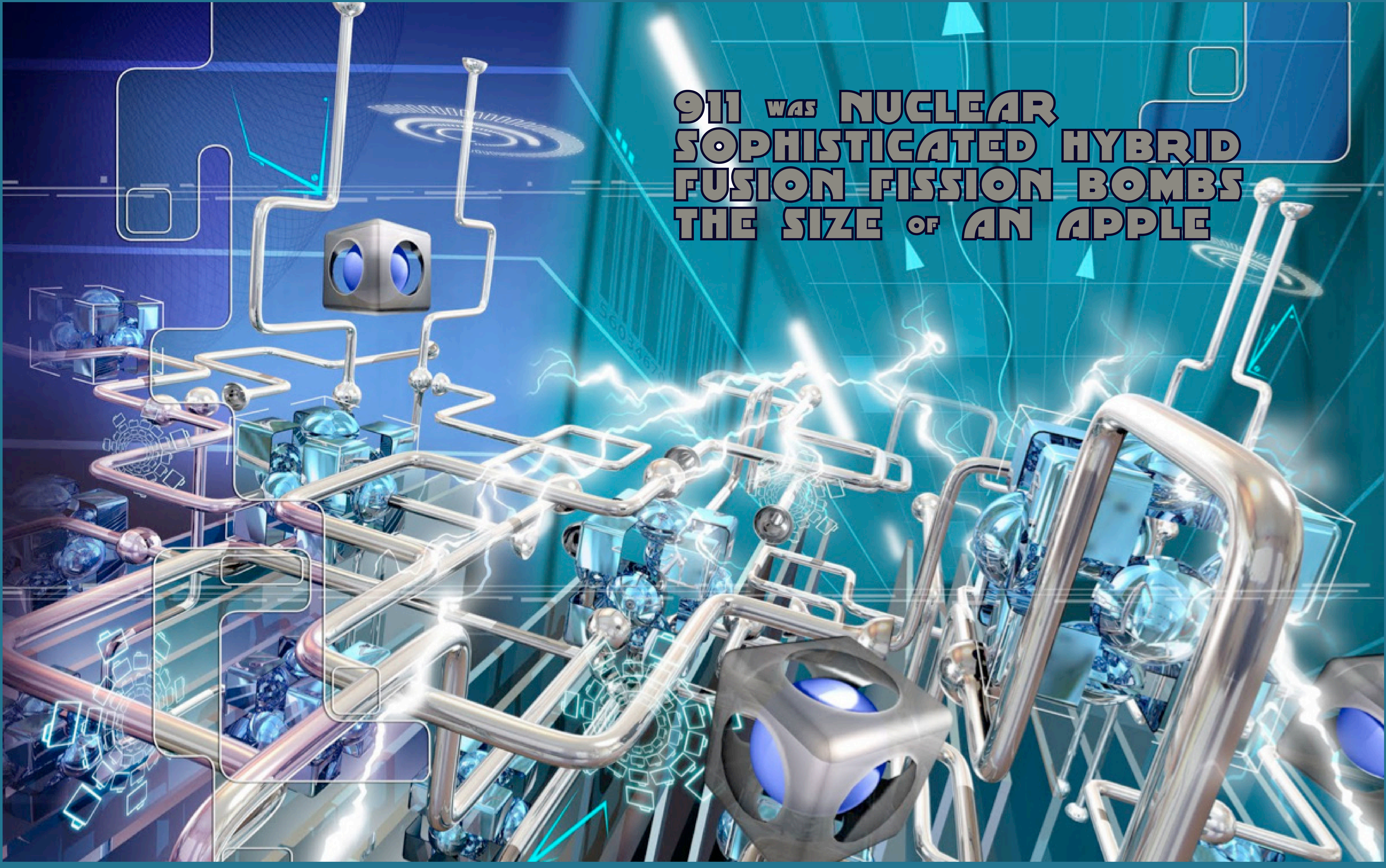
While I've spent my time now, about 10 years, on everything from planes to no planes, cell calls to no cell calls, dead hijackers to alive and living, breathing hijackers, thermite, thermate, super thermite, nanoenergetics, and every element from Antimony to Yttrium, I still find the dust analyses the best evidence in what is and always will be a crime of vast proportions and even greater consequences.

The dust, and the chemistry and physics associated with understanding what the various element levels mean, for example exploring the reasoning behind the anomalous Sodium and Potassium levels, far too high to be connected in any way to a building demolition, is something I find fascinating. The same is true for the Tritium, Thorium and Uranium levels. They can't be explained away with theories because their levels across lower Manhattan are unexplainable by mainstream science by anything other than a nuclear event. Lithium, Lanthanum, Yttrium, Cerium, Molybdenum, Vanadium, Zinc and other elements in the dust can't be explained either except for a nuclear event and they speak volumes about what happened that day. They simply can't be ignored.

The unfortunate problem we have is that these issues are an aggregation, a multiplexed and elaborate scheme of sciences and technologies that the average person has little working understanding of and even less desire to perform the difficult and time consuming 'work' of reading chemistry and physics books for months and then years on end. People don't have that kind of time.

For those of you without the time there's this book and the numerous links within.




911 WAS NUCLEAR
SOPHISTICATED HYBRID
FUSION FISSION BOMBS
THE SIZE OF AN APPLE

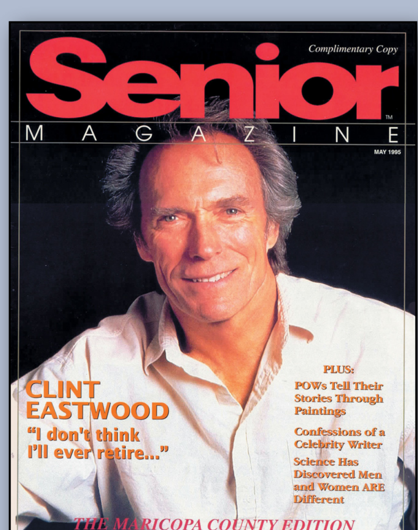
ZOOM

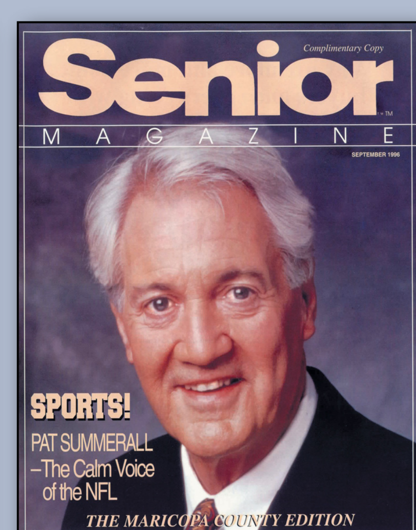

ZOOM

Meanwhile, the elite get a pass and vacation on the beaches of Tel Aviv (*below*), Dubai and Monaco

I WAS A SHEEPLE, ONCE

I am the former founder and publisher, retired, of an award winning magazine for senior citizens, Senior Magazine Arizona. This is me (*below left*) interviewing the late Senator Barry Goldwater in 1996, two years before his death. Issues of my magazine are below. This was the senators last public interview. He was exhausted after almost 3 hours with me because he did most of the talking, which was a great pleasure for me. I felt extraordinarily fortunate to be speaking with this 87 year-old statesman who participated in and was privy to much that happened in the history of our country. I had interviewed many others but none with this 87 year-old's constant, consistent and tremendously tenacious impact across our society and all social strata of our societal structure.





I published that interview in October of 1996 I believe it was. He walked in on crutches after two hip replacements of course, assisted by a nurse/aid, and there we sat alone with the exception of my photographer who snapped 200 pics and we discussed his youth.

We talked about growing up in Phoenix between 1919 and 1927 when he was between 10 and 18 years old and we talked about his love for and his history with Ham radio. He once shipped an iron lung, he and his Mom, via train and ship from Phoenix to South America and then on the backs of donkeys up a steep mountain trail through the jungle to a nunnery in a remote are of Nicaragua, I believe it was. Don't quote me on the particular country.

He used to hold the solder, after walking along the canal on his way home from school, for the guys building the first radio station in Phoenix. They let him hold the solder. Senator Barry Goldwater at 14 years old. The interview was granted because I promised not to discuss politics. He wanted to discuss something of importance and convey that quality with eloquence. So we discussed life as it once was.

ABOUT ME
THE WHOLE TRUTH
NOTHING BUT THE TRUTH

I bought two new dress shirts and four pair of socks on the way home that evening even though I already had two or three with the labels still on them hanging in the closet and maybe 100 pairs of socks. My concerns at that time were with raising my daughter as a single parent, my business, clothes, my house, my car and money; just stuff. I was the ultimate consumer of corporate goods. I was a sheeple; a master sheeple.

I have pot arrests behind me, I owe child support and was arrested more then 25 years ago as a manager in a telemarketing company for fraud. I'm no angel. I tell you this should my integrity be questioned so let's establish a few facts.

911 is of the utmost importance to me personally and I simply want to know how the event, the Twin Tower demolition in particular, was managed. Those past events in my personal life considering the references I use in this text herein should be immaterial. They are to me. We all make mistakes. Those that use this type of information about me to discredit me only discredit themselves.

MEXICO
THE PATH HERE

In 2005 I retired and moved to a small beach community on the Sea Of Cortez; Puerto Penasco, Mexico, to sit and think. I lived there for almost 3 years on and off and traveled back and forth to the states frequently but just for the day. One didn't need a passport then and where I went, Puerto Penasco, had only one lonely lane headed in,. Then it was another 100km from the border through a surreal moon-like desert and volcanic landscape which ended at an isolated little fishing community where the

internet speed made ours look like molasses in spite of the fact that most of the roads are dirt. Some are deep sand. Needing to be careful where you drive is an understatement, unless you have 4 people in the back seat to push you out of the occasional dune. I drove a red 4-wheel-drive Dodge Ram 1500 (*above right*) and still buried myself to the chassis 3 or 4 times in some remote, desolate area. Yet life in Mexico was the best.

Penasco is Al Capone and Jim Thompson's old hangout. They built a casino, a hotel and drilled a well for fresh water in the 1920s in Penasco and flew wealthy Hollywood starlets, politicians and other elite down to gamble, drink, smoke pot and have fun in the sun in this sleepy little Mexican fishing village. I've always felt more at home in Puerto Penasoc than anywhere else. Of course I had ben going there on weekends for over 20 years. Google Jim Thompson.

Life in Mexico was idyllic and the food was clean and cheap. The fish, well, it can't be described in words. And the internet rocked. The speed of sound, almost. And there were never people on the beaches if you lived there like I did and knew where to go. Life was unlike life here in every imaginable way I'm sorry to say.

I was an illegal alien in Mexico after 6 months and when I went to the Emergency Room one day they wouldn't charge me. I tried to pay in dollars and then pesos and they wouldn't hear of it. But they did treat me exceptionally well and the facilities were at least as clean and well equipped as here in the USA and 'Rocky Point' as it's normally called is a very small community of just 45,000 people.

I sat on deserted beaches most every day. I spent time with many friends there and relaxed, for once in my whole life, without a care in the world ...

Eventually I recognized that the world wasn't what I had thought it was for almost 50 years and that was heartbreaking. Everything, bar none, was a lie. That was also the beginning of a very long and arduous journey that encompassed years because I had decided to spend my full-time efforts investigating 911.

911 happened in my lifetime as an adult and I happened to be home with the television on and saw everything broadcast for the next several hours, glued to the TV as any sheeple would be, yet I do remember the media broadcasts that day and their themes. Sitting on the beach for extended periods can end up being more then troublesome.

A DIFFERENT PERSPECTIVE

I didn't want to parrot the views of others; I wanted to perform an independent investigation of all of the evidence within certain parameters without considering the final conclusions of anyone else but, rather, considering all of them while still developing my own personalized and autonomous convictions and sentiment regarding the details of the demolition. I made a personal oath not to use video to develop my assertions although there is one video link in this text. I think it's a relatively unimportant video and inconsequential overall and it's not necessary to watch it to understand this story nor does it define any of the assertions within this text.

I also decided to use only technical data from the best possible sources such as Lawrence Livermore National Laboratories, Sandia, Oak Ridge, the USGS, UC Delta Davis Group, Perdue University Physics Department and many other similar sources noted and cited herein.

That strategy led me on a multi-year, often grueling, always tedious and generally exciting quest. What I learned a very, very tiny bit about besides a new language (*physics*) is that physics and chemistry are as easy as changing a tire, which isn't so easy for a 50+ year-old guy with a bad back. Yet I'd rather do this than change a tire every day. The result has been a dozen books on 911. Ground-breaking books unlike any others written on this subject. My forensic financial investigation is a staggering synopsis of reality.

It's my sincere hope that this free eMagazine (*all 20+ books I've penned are free, as the truth should be*) will cause you to think and more importantly perhaps it will cause you to stop believing what others say regarding 911, including me, and that you might begin investigating the technical details of this event on your own. All of the data is out there on the internet and the evidence is in the dust. This eMagazine would be 25,000 pages if I provided it all so there's much more for you to learn then just what's within the pages of this eMagazine.

If at some point in the future a real, independent, civilian controlled investigation proves me wrong the response I have is that I tried, I thought I did the best I was capable of doing and I believe every word I've written. I don't have great expectations towards that ever happening. I believe the overall conclusions within this text are accurate. 911 was nuclear.

DNA at nano-scale


"I FOUND A WOMAN IN THE RUBBLE,
BURNED, IN AN AIRPLANE SEAT,
HER HANDS BOUND..."
Quote From A New York City First Responder