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Scary Things That Don't Exist: Separating Myth From Reality in Future WMD

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In the future anything is possible, but not all things are equally possible. This may be, in my view, the most important thing to remember when it comes to thinking about future weapons of mass destruction (WMD). I approach this topic neither as a scientist nor as a government official, but as a writer who has spent much of the past decade looking at how the US military makes decisions about science and technology investments and, in part, how those investments reflect its thinking about future threats, including potential future WMD. I have come away from this experience deeply skeptical of those who trumpet the advent of frighteningly new or exotic WMD and of unbounded technological optimism that we can defeat such threats.

As a reporter and at times as a participant, I have sat through many panel discussions about future threats and technology, and I have always been struck by how little dialogue we have about how to evaluate those threats. That is unfortunate, since all too often it leads to a limited discussion and detracts attention from a much-needed debate about how we should plan our investments in future science and technology. Most memorably, I recall sitting in the audience at a seminar on space weapons as a television reporter questioned a missile defense critic. How, the reporter asked, could this critic—a prominent scientist and longtime Pentagon weapons adviser—say that the missile defense system under discussion would never work, given that experts had been wrong so many times in the past?

Without rehashing the pros and cons of that particular discussion, I would like to use it as a launching point to discuss future WMD and, more importantly, how the national security agencies gauge risks about such threats—perhaps many years in the future—and how they plan for responding to such threats. Those who want to believe that any development is not just possible, but equally possible, typically quote (or misquote) at least one of the following three examples: Lord Rutherford's doubts about extracting energy from the atom; *The New York Times*' skepticism of the Wright Brothers' quest for manned flight; and finally, the cringe-worthy "Galileo burning" metaphor often evoked by the "lunatic fringe" to justify some gravity-defying or physics-violating concept. These analogies—now clichés—are often used to demonstrate that experts are often wrong and anything is possible. But under this line of (il)logic, anything is possible because the future is a series of black boxes, from which surprises can pop at any minute.

In fact, we know this is not the case. Nuclear weapons were a surprise to the public who had been carefully shielded from the Manhattan Project. However, the knowledge base underlying nuclear weapons—neutrons and then nuclear fission—was certainly not unknown to those scientists familiar with the fast-developing field of nuclear physics. (Rutherford's statement, it bears noting, had been made *prior* to the demonstration of fission.) In the case of manned flight, it was a newspaper, not experts, that expressed skepticism. The Wright Brothers' success in manned flight was not wholly a surprise to those who followed the field. Galileo, of course, was condemned primarily by the Church, not by other scientists. In summary, this form of selective quoting is used to bolster the illogical notion that we cannot (or perhaps should not) judge the risk or likelihood of future events, because anything is possible. I would reiterate here, again, that not everything is equally possible.

This is not a startling revelation, but it is one that I think needs to be emphasized. At the heart of many of the Pentagon's science and technology debates is the question of "technological surprise," which—roughly translated—means the fear that an adversary may unexpectedly overtake us, much as the public feared the Soviet Union did with Sputnik fifty years ago. What is the framework we can use to judge the threat of such a surprise occurring again? In fact, such a framework already exists. A few years ago, then US Secretary of Defense Donald Rumsfeld attracted widespread attention for his seemingly convoluted remark about the "unknown unknowns." In fact, his remark made sense to engineers, for whom the unknown unknowns are the problems they do not have enough knowledge about to design around (in contrast to the known unknowns, which are problems they know they do not understand and for which they can overdesign).

Along this same line of thinking, when it comes to WMD, there are things we know and can plan for—such as a WMD attack involving nuclear weapons; there are known unknowns—such as the probability that a terrorist has a nuclear weapon; and then there are the unknown unknowns—which could be some form of future or exotic WMD. So the real question is: How can we best prepare for the known unknowns, and how do we deal with unknown unknowns? More succinctly, should we even worry about the unknown unknowns? This is essentially a question of risk management, and there is no reason why the Pentagon should deal with risk any differently than the airline industry, fund managers, or private companies. Meaning you prepare for the known risks; you overprepare, if possible, for the known unknown risks; and as for the unknown unknown risks, well, you try to understand those risks as much as possible, but you don't bet the farm on them.

Unfortunately, the Pentagon and other national security institutions have not always been that logical about their approach to risk, and there are lessons to be learned from exploring the failures. For the purposes of this essay, I will examine a few areas in which the government's assessment of future WMD threats—and possible countermeasures—has fallen short.

Advanced Energetics: Isomer Bombs, Cold Fusion, Antimatter

In the summer of 1998, Carl Collins, a professor at the University of Texas at Dallas, conducted an experiment at his lab that, for a brief period in time, seemed to herald a new era in weapons of mass destruction.[1] Collins claimed he was able to use low-energy photons from a used dental X-ray machine to accelerate, or "trigger," the decay of a nuclear isomer of hafnium-178; a result that, if true, could potentially lead to a new generation of weapons based on this highly energetic material.

Within months of the 1999 publication of the "dental X-ray experiment," Collins' results garnered attention from media, government, and the scientific community, eventually leading to a program sponsored by the Pentagon's Defense Advanced Research Projects Agency (DARPA) to develop a "hafnium bomb." There was, at one point, a great deal of enthusiasm about the potential of nuclear isomers, and especially of hafnium, to provide a revolutionary military capability (or conversely, to pose a threat in the hands of an adversary). In speaking about the potential of high-energy-density materials like nuclear isomers to advance from basic science to weapons, the Pentagon's Militarily Critical Technologies List in 2002 offered this historical lesson: "[W]e should remember that less than 6 years intervened between the first scientific publication (in *British Nature*, January 1939) characterizing the phenomenon of fission and the first operational use of nuclear weapons in August 1945."

Yet there are many differences between nuclear isomers, the dental X-ray experiment, and nuclear fission. In contrast to fission, in the nearly ten years that have passed since the hafnium results were first reported, independent experimenters have been unable to replicate the dental X-ray results, and scientists have raised a series of unanswered theoretical objections to the original work. Two government-sponsored reviews of nuclear isomers—one by the Institute for Defense Analyses and another by JASON, an independent advisory body—raised scientific and technical objections to the concept of a "hafnium bomb." Even an internal review sponsored by DARPA to evaluate the original and subsequent experiments expressed grave doubts about their validity. Congress eventually stopped funding the program and, although official interest in the military potential of nuclear isomers continues, active work on a hafnium bomb appears to have ceased.[2]

In defending its work on the controversial hafnium bomb, DARPA acknowledged the criticism but insisted that the potential for "technological surprise" by a foreign adversary justified the work. At the heart of the hafnium debate, then, was a question of risk; specifically, in spite of the extreme likelihood that the 1998 experiment was flawed, there was a chance that a new type of WMD was possible.

How serious was this risk? How much funding (and attention) should the Pentagon give to something that could lead to a new generation of WMD (nevermind that it would cost countries $1 billion a gram to produce the hafnium isomer)? In its initial stage, it was certainly not ridiculous—even over the objections of some scientists—to explore the military applications of hafnium-178. However, there were two inherent problems with the DARPA program. First, DARPA did not try to validate what was already an unlikely experimental result to see if there was any substance to the original claims. That would have meant funding an independent research group to attempt replication of the 1998 results. Not only did DARPA not pursue this route, it funded only those experimental researchers who had been involved in the original work. The second major problem was that the program was narrowly focused on the 1998 dental X-ray experiment to the exclusion of other nuclear isomers and/or other experimental approaches. Even if one believes in the potential of nuclear isomer weapons and its risk as a technological surprise, DARPA's approach did not seem to be an effective way to mitigate that risk.

Nuclear isomers are not the only exotic or far-reaching areas of science with potential military applications. Over the past year the Defense Threat Reduction Agency (DTRA) has sponsored a series of meetings on advanced energetics, covering such topics as nuclear isomers, cold fusion (also referred to as "Low Energy Nuclear Reactions"), and antimatter.[3] As DTRA's mission is focused in large part on counterproliferation, it is safe to assume the agency is interested in these areas of science as potential WMD. The goal, as I understand it from those who have participated in these meetings, is to understand if there is enough solid science in any of these three areas to justify even modest government investment. Frankly, I see nothing wrong with the military taking a broad view of such areas of science, be they fringe, frontier, or merely controversial. The Pentagon, in some cases, may not have the luxury of waiting for a scientific consensus before exploring some of these areas. What I would like to ask is this: Are they appropriately gauging the risk these areas of science really pose as WMD?

I have briefly discussed nuclear isomers, but how is cold fusion a security concern? There are at least two reasons for the military's interest: as a new energy source (something that is of increasing interest to the Pentagon, though perhaps not as much to DTRA) and, less likely, as a weapon.[4] Though often ridiculed as pseudoscience, cold fusion continues to attract the attention of credible scientists who pursue work in this field and report new results. Is cold fusion too far out on the edge to warrant Pentagon support and attention, or does it belong to a high-risk, high-payoff category of research? As we do not have a "cold fusion program" on the order of the now defunct hafnium isomer program, it may be too soon to ask that question. Basic research, with appropriate peer review and aimed at replicating credible results, is certainly a worthy goal in any field. But it is not clear—at least from the open literature—how cold fusion could pose a future WMD threat.[5]

In the case of antimatter, the question is whether this area of work could lead to a future generation of weapons. As Keay Davidson of the *San Francisco Chronicle* has written, the military has conducted at least some exploratory work in this field: "More cataclysmic possible uses include a new generation of super weapons—either pure antimatter bombs or antimatter-triggered nuclear weapons; the former would not emit radioactive fallout. Another possibility is antimatter-powered 'electromagnetic pulse' weapons that could fry an enemy's electric power grid and communications networks, leaving him literally in the dark and unable to operate his society and armed forces."[6] The main problem with the "antimatter bomb," however, is that there is no feasible way yet to produce—let alone store—antimatter in sufficient quantities to create a weapon. Scientists do not know when—or if—that technology will ever develop. So, in looking at this area, I would hope DTRA is gauging the immediate risks rather than betting on the future.

Is it wrong for the military to explore or express interest in these far-out topics? No, but is the Pentagon's investment appropriate to the risk? Put differently, what are the chances that any of these areas may actually lead to future WMD? At what point does the Pentagon say, "We have invested enough to know the risk is minimal."

Neuroweapons: Time for Tinfoil Hats?

In 2006 I sat across from a former member of the Duma, Russia's parliament, who informed me that the world faced an arms race in mind control weapons, or "psychotronic weapons," as they are often called in Russia. I still do not know what sort of weapons he was referring to, but neuroweapons, or weapons that target the brain or the central nervous system, have certainly posed at least a theoretical, or perhaps fanciful, threat for many years. They have also brought us many conspiracy theories and jokes about "tinfoil hats."

The concept of "mind control" evokes rich imagery of *The Manchurian Candidate*, government-sponsored LSD experiments, and exotic microwave weaponry. At least some of the work over the past few decades has been aimed precisely at mitigating technological surprise (which, at least in one case, did not exist). As I noted in an article for *The Washington Post Magazine* last year, one of the more significant Cold War-era "mind control" efforts was Project Pandora, a DARPA project that was launched after it was discovered that the US embassy in Moscow was being bombarded by low-level microwaves. Some US officials were concerned that an elaborate mind control project was behind it:

> In 1965, according to declassified Defense Department documents, the Pentagon, at the behest of the White House, launched Project Pandora, top-secret research to explore the behavioral and biological effects of low-level microwaves. For approximately four years, the Pentagon conducted secret research: zapping monkeys; exposing unwitting sailors to microwave radiation; and conducting a host of other unusual experiments (a sub-project of Project Pandora was titled Project Bizarre). The results were mixed, and the program was plagued by disagreements and scientific squabbles. The "Moscow signal," as it was called, was eventually attributed to eavesdropping, not mind control, and Pandora ended in 1970.[7]

Was it crazy in the 1960s to think the Soviets had engineered a microwave mind control device? Yes and no. Research during that decade on biology and microwaves was still emerging, and our knowledge of the biological effects of microwaves was quite limited. I suspect that even at the time, however, scientists in this field could have told the Pentagon that it was unlikely that the Soviets had mastered this area to the extent of weaponization. Nonetheless, to entertain the possibility and do our own research is certainly not beyond the pale of reason.

These days, however, the newspapers are filled with breathless articles on advances in neuroscience that might someday revolutionize the military. Some of these military technologies—in prosthetics, for example—do indeed look promising. But other technologies, particularly those touted as "mind reading" devices, are still quite far in the future. Detecting deception, either through thermal imaging, voice stress analysis, the polygraph, or more hopefully, using functional Magnetic Resonance Imaging (fMRI), all have potential homeland security applications. Yet, in the best cases, all of these methods also have flaws. In the worst cases, claims surrounding these technologies are not supported by the experimental evidence. It is not yet clear whether researchers can—beyond artificial laboratory settings—reliably use such devices to detect deception in real-world settings.[8]

While I am critical of some of the bolder claims relating to neuroscience, I do think that Pentagon funding in this area is warranted and in fact necessary. The potential applications are rich and, more importantly, this is precisely an area of "known unknowns" that research can benefit. Neuroscience is advancing at a remarkable pace, and agencies like DARPA have an important role to play in this field. Yet experts in the field readily admit our understanding of the brain is still quite limited in many ways. Could this also be an area that poses future threats, perhaps even a new form of WMD?

As the medical ethicist Jonathan Moreno writes in his recent book, *Mind Wars*, neuroweapons are theoretically possible:

> Based on work already done in the offensive biological weapons program of the former Soviet Union, scientists who are expert in biological weapons defense have worried aloud to me about the threat of technological surprise posed by advanced viral neuroweapons carrying synthetic genes coding for short peptides (short strings of biological active amino acids with biological activity) into the central nervous system.
>
> Inside the central nervous system, the technological surprise stems from designer peptides produced from synthetic genes that have effects quite distinct from those normally associated with the pathogen. For example, when produced in the brain, they could function as malign neuro-modulators, disabling brain functions by modifying the relationships and communications between neurons. In such advanced neuroweapons, the infectious pathogen is really just a Trojan horse, selected for its ability to get the synaptic gene quickly into a target it cannot otherwise reach.[9]

Moreno, however, is not suggesting that the US government pour money into neuroweapons or even into countermeasures. He is primarily exploring the ethical dimensions of such weapons and how technology, as it develops, will challenge our government and society. In any event, given that the Pentagon is now an important sponsor of neuroscience research (as Moreno points out), it would seem the potential for technological surprise is being addressed. If we are at the forefront of neuroscience research, we will be in a better position to anticipate and negate future threats.

I have no doubt that we will see exciting—and possibly frightening—developments in neuroscience. Will we someday have mind-reading machines? Weapons that precisely and effectively target the brain? Or what about militarily useful tools for altering behavior? Yes, perhaps—though I suspect neuroscientists will tell you many of these applications are a long way off. Perhaps instead of preparing for neurowarfare, we should fund the best neuroscientists in the field—not necessarily those who promise the most miraculous applications or foresee the worst disasters. We should—as in other areas of science—fund proposals that extend our fundamental understanding of the science and keep us ahead of the curve, both in civilian and military fields. We should also keep our tinfoil hats in check.

Predicting WMD: Lessons From Keegan's Laser

It is easy to make predictions that do not have end dates. Take for example the continuing chorus of writers who declare the advent of the mythical death beam: "Laser Weapons in US Sights" says one headline from October of 2003.[10] That's fine, except such headlines go back to the 1980s and even, in some cases, to the 1970s. No story better illustrates the danger of hyping future WMD than the strange history of Keegan's laser. This story first came to light in a 1977 article in the respected aerospace publication *Aviation Week & Space Technology* (a magazine I once wrote for), which published a lengthy article under the provocative title, "Soviets Push for Beam Weapon." The article detailed the concerns of Major General George Keegan, a former head of Air Force intelligence, who believed the Soviets had made a major breakthrough in laser weapons technology at a time when the United States was only at the very beginning stages of such research.

"The Soviet Union is developing a charged-particle beam device designed to destroy US intercontinental and submarine-launched ballistic missile nuclear warheads. Development tests are being conducted at a facility in Soviet Central Asia," the *Aviation Week* article claimed. "The Soviets also are exploring another facet of beam weapons technology and preparing to test a spaceborne hydrogen fluoride high-energy laser designed for a satellite killer role. US officials have coined the term directed-energy weapons in referring to both beam weapons and high-energy lasers."

With the power of hindsight, it is easy to mock these extravagant claims, but what about in the 1970s? Though many laser physicists at the time questioned the scientific possibility of this alleged breakthrough, General Keegan proved a committed proselytizer, as a *Washington Post* retrospective on the "death beam" recounted:

> Of all Keegan's obsessions, fear that the Kremlin was about to develop a particle beam

> weapon was perhaps the most consuming. He taught himself nuclear physics while still chief of Air Force intelligence in order to validate his theories. In 1978 he told CBS's "60 Minutes" that the Soviet Union had embarked on "the most gigantic scientific program of its kind in history" and that "time was running out for the United States." Standing in front of an artist's rendition of the particle beam project allegedly underway in Kazakhstan, Keegan described how the Kremlin was working on weapons that would "simply eviscerate" incoming US warheads.[11]

At issue was work at a secret facility in Kazakhstan appropriately dubbed P-NUTS (Possible Nuclear Underground Test Site), which was the supposed center of the Soviets' laser work. As *The Washington Post* noted on the P-NUTS' nuttiness: "Paranoia about P-NUTS helped stimulate American research in both particle beam and space-based laser weapons, culminating in President Reagan's decision to launch the multibillion-dollar 'Star Wars' program in 1983."[12] It turned out in the end that P-NUTS had nothing to do with lasers; there was no major breakthrough; and the United States' own laser weapon efforts proved quixotic at best. So, not unlike the Moscow Signal, which launched Project Pandora, Keegan's laser contributed to a program that focused on a nonexistent threat.

Hindsight, of course, is 20-20, and my purpose here is not to vilify poor General Keegan (now deceased), but rather to ask if there are any hard lessons to be learned from this episode. There are interagency politics to consider (Keegan's laser played well into the hands of those looking to increase their budgets), but certainly, it would have been helpful to ask some basic questions about risk: What breakthroughs would the Soviets have had to make in order for the laser and particle beam to become reality, and how likely did experts think those breakthroughs were? In the case of laser weapons, it is unlikely, as critics pointed out at the time, that another country—unbeknownst to us—could have made an advance in basic science that was completely foreign to the rest of the scientific world. In the thirty years that have passed since Keegan's laser was exposed, no country has deployed a high-power laser weapon.

The Force Field: The Myth of the Future WMD Defense

In talking about mythical threats of future WMD, it is important to discuss—even if briefly—research the US government is engaged in to counter WMD. In the case of some exotic future WMD, such as isomer bombs and antimatter bombs, it would be, needless to say, a bit odd to begin thinking about defenses. But in some cases, this work makes a great deal of sense; the national laboratories, for example, are focusing more resources on nuclear attribution that allows scientists to trace the origin of nuclear material. In the event that terrorists or some unknown group set off a nuclear weapon, the government could trace its origin. With nuclear weapons—even nuclear terrorism—we have ways to mitigate the risk of their use.

What about the unknown risks of future threats, threats that are not as easily debunked as hafnium bombs or as far off in the future as antimatter bombs? Should we—or could we—develop methods to detect the signature of exotic WMD, or shields that defend against such weapons? In a sense this leads us back to former Defense Secretary Rumsfeld's strategy of capability-based, as opposed to threat-based, planning. Capability-based planning is the concept that underlies Rumsfeld's approach to planning for and acquiring systems such as ballistic missile defense. Such an approach is not based on a specific known threat but, in Rumsfeld's words, on "the kinds of things that need to be deterred and dissuaded and the kinds of things that will enable you to—if you have those kind of capabilities with your allies—reassure your allies, that the prospects for a reasonably peaceful and reasonably stable world are good."[13]

Capability-based planning, when applied to acquisition, was supposed to be an argument for "spiraling" out technology as soon as it becomes available, something that can make a great deal of sense. In its simplest interpretation, however, this argument was also designed to make the case for national missile defense since such a system could defend against any number of WMD threats, so long as those threats are designed to arrive in the reentry vehicle of a ballistic missile. My trouble with this approach is that capabilities in which the Pentagon could invest are infinite, while our resources are not. Although I think there is a role for missile defense in our national security strategy, at $10 billion a year it is unclear that this is the capability that is most needed when compared to other capabilities our nation might like to have. More troubling, however, is that such a system is based ultimately on a single known threat: long-range ballistic missiles. In other words, it is difficult to avoid talking about threats.

What about protecting against the ultimate source of any attack: the people who perpetrate it? It would be nice, of course, to have technology that could somehow track these people down ahead of time, regardless of the WMD they may have. At face value, this proposition sounds quite reasonable. After all, we may not be able to predict the future WMD that will be used against us, so perhaps we should go to the source. Such thinking, however, should properly evoke skepticism if it is rooted in the misguided belief that there is some technology out there that can render us invincible against the threat of terrorism, be it on a small or a large scale.

Yet such "silver bullet" technologies are precisely what are being sought in some cases. In an interview last year, a senior military scientist evoked science fiction and Star Trek in one such technology endeavor:

> I want a "Tricorder" for evil. I would like to be able to detect intent. You have to understand how a person is motivated. Why would he or she want to become a terrorist? That is all tied into that linkage of tribal, cultural, social-economic and religious dynamics. How do those play together so that a person would want to become a terrorist and suicide bomber?[14]

This line of thinking extends to other services and agencies. For instance, the Night Vision and Electronic Sensors Directorate of the US Army Research, Development and Engineering Command released a Broad Agency Announcement in 2006 under the rubric "BadGuyology," a trademarked term to describe technology that, as the name indicates, picks out the bad guys (or "the visualization of un-natural human behavior associated with this awful action"[15]). This, you might say, is the Army's version of the Tricorder. The connecting theme across these agencies and services is a desire to do the near impossible: detect a terrorist with the wave of a wand, thereby reducing the "human problem" to a simple technological solution.

While it may seem odd to talk about this work in an article on future WMD, I think it actually ties in well with how the Pentagon is thinking about future threats, particularly those that might arise from terrorist groups. It is precisely this "human problem" that the national security institutions are trying to conquer—by applying science and technology. The most intriguing of the Pentagon's and other departments' forays into this area is the concept of the "human terrain," which seeks to "better understand how individuals, groups, societies, and nations behave, including adversaries, allies, others, and even the United States itself."[16]

In some cases this work involves simply using the social sciences to help the military operate more effectively in foreign countries—a worthy and sensible goal. The idea behind some of this work, however, is that there may be a way to develop technologies that precisely track terrorist networks or even predict the people who join them. Rather than a "Tricorder for evil," they are hoping for a crystal ball.[17] Under the mantra of human terrain, we now see a proliferation of programs combining the social and physical sciences and aimed at developing predictive models and forecasting. Not unlike Isaac Asimov's *Foundation* series and its concept of psychohistory that predicts group behavior, the Pentagon wants technologies that will predict future attacks. Are such technologies realistic?

Not everyone is convinced. As I write in a recent article in *Discover* magazine:

> Longtime national security analyst William Arkin is skeptical of much of the new human terrain work, calling it a "dream counterterrorism program" that seeks to combine an array of technologies into a silver bullet that will solve the problem of terrorism. "Those technologies are interesting and worthy of pursuit, but my guess is that they are a poor replacement for examining why it is that terrorism exists in the first place," Arkin says. He points to the billions of dollars being poured into developing a biometric database in Iraq that will be used to identify and track individuals. This sort of approach, he says, is based on "the belief that they can make a database of the entire planet, and thereby that will

> set us free." But even if such work is worthwhile, "it's also important to bring it down to Earth," he says. "9/11 was successful because it was a diabolical plot using the most conventional of weapons. It was not successful because of some technology they acquired."[18]

Better military technology, while necessary and desirable, will not ultimately be the solution to terrorist threats. Is a "Tricorder for evil" realistic? Probably not. I do not mean this as criticism of those proposing the ideas. It is hard to blame technologists in the military for pursuing ambitious visions; this is what they are tasked to do. The focus now is terrorism and they are valiantly trying to come up with solutions with the only tool in their arsenal: technology. But taken to the extreme, why doesn't the military reach for that brass ring: a beam gun that makes people like us? That is equally unlikely, but it underscores my larger point: We are facing what I call the "The Force Field Myth." No technology can solve what is essentially a human problem.

What Next?

We often remember the symbolic importance of a distant event but forget the more recent past. The Soviet Union's launch of the Sputnik satellite some fifty years ago is the best example of this peculiar form of myopia. Though now widely heralded as the quintessential "technological surprise," it is less often mentioned that Sputnik presaged a number of mistaken warnings of nonexistent technological surprises, leading to mineshaft gap-like crises, from the "missile gap" to Keegan's laser.

Skepticism aside, are technological surprises still possible? Is it worthwhile to invest in defenses against these technological surprises? Of course, but what do we mean by "surprise," and what can we reasonably expect such defenses to do? If we really look at the Sputnik surprise, certainly the concept of launching satellites into space was far from foreign. Rather, we had incomplete intelligence about what an adversary was capable of, and had thus made some incorrect decisions about what our own investment priorities should be. The world is clearly a dangerous place, full of such surprises: scientific, technical, and technological. Charles Herzfeld, a former DARPA director, recently told *Computer World* that technological surprise along the lines of Sputnik is still possible. "Yes, I expect it," he said.[19]

Are there other surprises out there that we should be imagining, particularly in the realm of technology or future WMD? The quick answer, of course, is that there are, but we do not know what they may be. The essence of the future is that it is unknown and unknowable with any great degree of precision. It is a mix of known unknowns and unknown unknowns. In such a complex system, even a seemingly small variable can have a huge impact on a projected outcome—crystal balls notwithstanding. We have an array of new threats as well as old threats that still exist, and some may argue that new types of threats, such as global warming, should also now be considered on par with WMD.[20] But we can think about—and plan for—those future threats that we think may be likely, and consider strategies for dealing with those threats that, though unlikely, are still possible. And perhaps we can even devote some small amount of energy to imagining futuristic threats—science fiction scenarios if you will—but I would argue our efforts in that area should match, and certainly not exceed, the actual possibility of such a threat emerging.

Nor do we necessarily need to know the exact type of WMD we face in order to prepare for it. Looking at the catastrophe wrought by Hurricane Katrina in New Orleans, we have evidence of our frail infrastructure, even when exposed to predictable shocks (the devastating flood in New Orleans hardly came as a "surprise" to many). And as last year's transatlantic flight of an Atlanta lawyer with an antibiotic resistant strain of tuberculosis demonstrates, if we are not prepared for even the most basic contingencies, then worrying about exotic new viruses is almost farcical.

Sometimes the surprises—and threats—that we face do not lie in traditional concepts of innovation. The 9/11 commission, in its final report, speaks of a failure of imagination being one of several key failures that led to the United States being blindsided by the terrorist attacks of 2001. I would argue that asking whether technological surprise is still possible is not the right question (of course it is possible, as Herzfeld notes) and belies a lack of imagination. It is better to ask, what is the chance of such a surprise? In what areas are these surprises most likely to take place? Finally, how best should we prepare for and, if need be, respond to such surprises?

The terrorist attacks on New York and Washington were a surprise, but I would argue that they also forced us to redefine and broaden the scope of what we consider WMD. Weapons of mass destruction, and more importantly, mass disruption, need not be created by the splitting or fusing of atoms, a new-fangled virus, or even a chemical compound. It can come in the form of minimally trained terrorists armed with box cutters attacking our country's most vulnerable points. Yet we should also be wary of turning 9/11 into the modern day equivalent of the clichés I outlined earlier. Rather, we should seek to understand the lessons of the terrorist attacks.

What, then, are we to make of future WMD? It would be naive to presume that there is zero possibility that some nation, or even some group, could develop a new, exotic type of WMD. Though it is less likely to be high-tech than low-tech—as we have seen with the spread of improvised explosive devices in Iraq—we should not assume that the unlikely is impossible. Since a chimerical "force field" is not likely to emerge, what should we do to prepare for future threats? Nothing? No, I am not advocating blind passivity. Since there is no silver bullet, the best way to defend against future WMD threats is to ensure the strength of our nation's scientific and technical base; to see that our defense and military agencies employ and support the best and the brightest scientists and technologists; to guarantee that our defense industrial base is sufficiently robust and flexible to respond quickly to the unknown; and to make sure that our military institutions continue to understand the importance of having the best scientific and technical advice. All of that, however, also requires a political leadership that values the role of science and technology and provides adequate funding and oversight.

Though I have discussed here some of the failures in past policy, the Pentagon has also produced some of the most advanced technology—both in the civilian and defense spheres. It has provided the United States with the world's most powerful military force, even if it has not made it invincible. I believe we should invest more, not less, in basic scientific research and development, and that we should direct those investments to creative and farsighted scientists and engineers. It is true that the future truly is unknown, but that is all the more reason for us to understand and prepare for the risks. But dreams of "evil detectors," fanciful notions of force fields, and fears of isomer bombs may not be the best guide for such investments.

Looking at risk in a measured fashion—and in investing in those areas most likely to protect our nation against those risks we are most likely to face—will continue the Pentagon's legacy of successes into the future and help us avoid repeating its past failures. This may not guarantee our future security—because there are no guarantees in the future—and technology is not always the solution. However, it will help minimize the risks that we do face and give us the best odds of adapting to future threats, be they from WMD or from some as yet unknown danger to our safety and national security.

Endnotes

[1] For background on this controversy, see author's article, "Scary Things Come in Small Packages," *The Washington Post Magazine*, March 28, 2004.

[2] For a complete history of the rise and fall of the hafnium bomb, see author's book, *Imaginary Weapons: A Journey Through the Pentagon's Scientific Underworld* (Nation, 2006).

[3] Author interviews.

[4] Though scientists working on cold fusion have alluded to weapons applications in author interviews, I have not seen any references to published or peer-reviewed work that would support such a contention. If the possibility exists, I would presume that even experts in the national security field would require more than anecdotal evidence.

[5] One could suggest that there is classified knowledge about cold fusion reactions, but that is no more or less credible than a conspiracy theory, in my view.

[6] Keay Davidson, "Air Force Pursuing Antimatter Weapons," *San Francisco Chronicle*, October 4, 2004.

[7] Author's article, "Mind Games," *The Washington Post Magazine*, January 14, 2007.

[8] For example, see Margaret Talbot's article, "Duped: Can Brain Scans Uncover Lies?" *The New Yorker*, July 2, 2007. She notes that one expert's criticism "suggests that fMRI technology, when used cavalierly, harks back to two pseudosciences of the eighteenth and nineteenth centuries: physiognomy and phrenology. Physiognomy held that a person's character was manifest in his facial features; phrenology held that truth lay in the bumps on one's skull."

[9] Jonathan Moreno, *Mind Wars: Brain Research and National Defense* (Dana Press, 2006), pp. 177-178.

[10] CBS News, October 20, 2003.

[11] Michael Dobbs, "Deconstructing the Death Ray; We Were So Scared of the Secret Soviet Weapon, We Spent Billions. Oops." *The Washington Post*, October 17, 1999.

[12] Ibid.

[13] Media availability with Secretary Rumsfeld, June 5, 2001. Available online at: *https://www.pentagon.mil/transcripts/2001/t06052001_t603rums.html*.

[14] "Interview With Starnes Walker, ONR Technical Director and Chief Scientists," *CHIPS Magazine*, October/December 2006.

[15] Issued by US Army Research, Development and Engineering Command, Night Vision and Electronic Sensors Directorate, Fort Belvoir, Virginia, Broad Agency Announcement, W15P7T-06-R-P816, March 2006.

[16] Defense Science Board 2006 Summer Study, "21st Century Strategic Technology Vectors," Vol. III, Strategic Technology Planning, 2006.

[17] The idea of predictive modeling is being applied to other areas as well, and the notion of a "crystal ball" is actually used in a recent DARPA proposal for mission planning. BAA 07-56 Deep Green Broad Agency Announcement (BAA).

[18] Author's article, "The Dark Side," *Discover*, October 2007.

[19] "The I.T. Godfather Speaks: A Q&A With Charles M. Herzfeld," *Computer World*, September 24, 2007. Online at: *http://www.computerworld.com/action/article.do?command=viewArticleBasic&taxonomyId=13&articleId=9035398&intsrc=hm_topic*.

[20] For example, the *Bulletin of the Atomic Scientists* last year decided to add global warming, along with its traditional focus on nuclear weapons, to factors affecting its iconic Doomsday Clock.

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