

# STS 152: Nuclear Weapons, Risk and Hope

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Handout #2, September 30, 2010

## **Reading for next class**

Read this handout.

Make sure you've completed the required reading from handout #1.

Read the short TIME magazine article that I emailed to the class. Do you agree that "It would be nice if the North's nuclear-armed government really were unstable"?

## **Overview of handout**

As noted in handout #1, nuclear risk has two components:

How destructive are nuclear weapons?

How likely is it that they will be used?

The last handout focused on the first question, while this one focuses on the second.

## **State diagrams**<sup>1</sup>

Most people have difficulty envisioning both the negative possibility of a nuclear war and the positive possibility of a world free from the nuclear threat because they implicitly think in terms of the overly simplified diagram shown below:

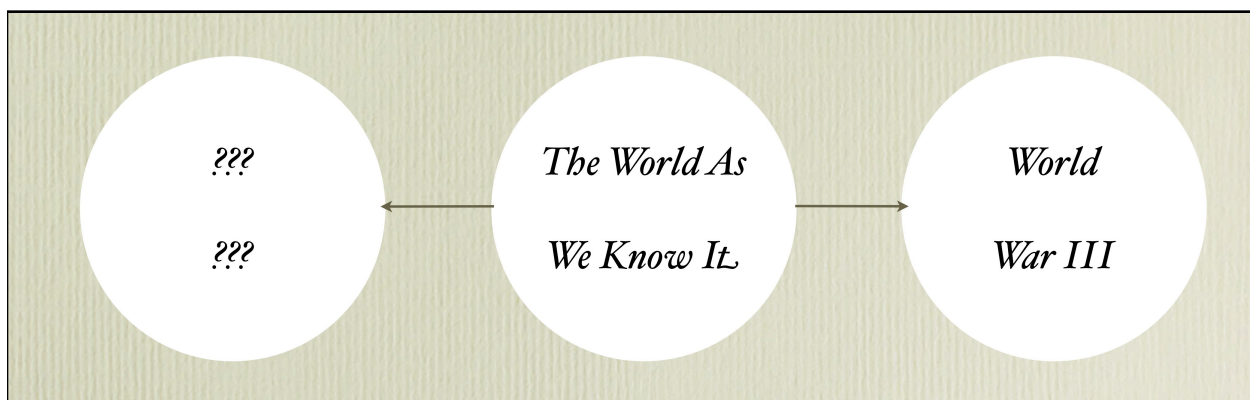


Figure 1. A simplified state diagram

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<sup>1</sup> State diagrams were also used in the required reading from handout #1, "Soaring, Cryptography and Nuclear Weapons." That article was written two years ago and uses an older model. I plan to incorporate the newer diagram used here when I get time to do a rewrite.

In terms of the negative possibility, they tend to think of a sudden jump from the world as we know it to World War III, and understandably have difficulty seeing how a day with no major problems could suddenly turn into a nuclear nightmare. In the positive direction, most people have difficulty even describing the goal, hence the question marks in that circle. Those who do venture to describe it, have different visions of what it might be. Some say that state <sup>2</sup> will require ridding the world of nuclear weapons, others that it will require world peace, and yet others that it will require some form of world government – all of which are rejected by most people as naive and unachievable. Both the negative and the positive possibilities are better seen via a second diagram, shown below:

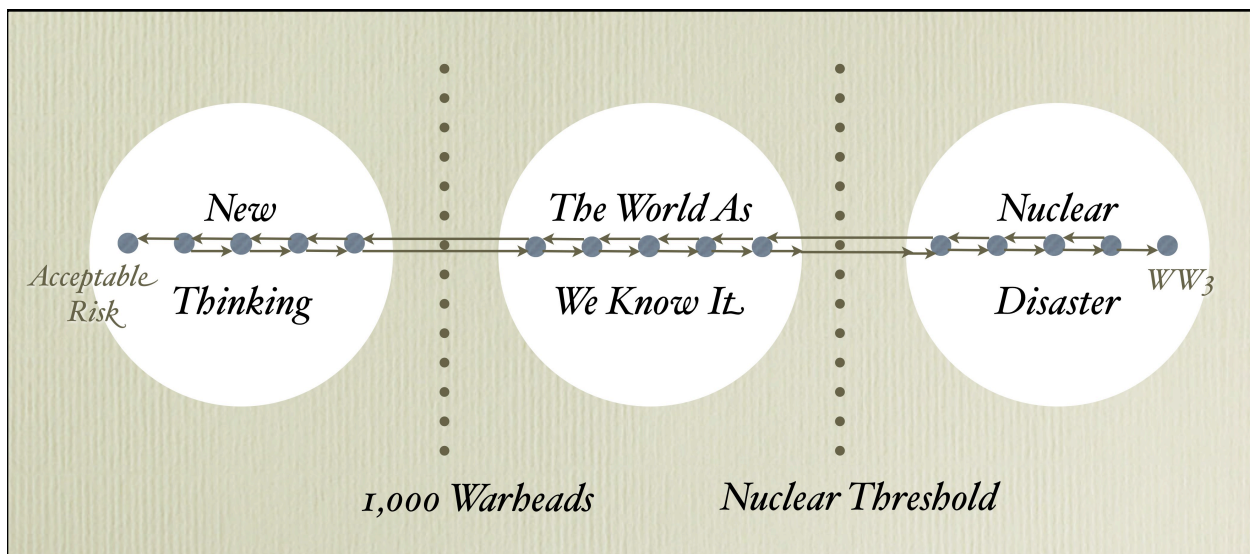


Figure 2. A more accurate state diagram

The world as we know it is really a super-state, consisting of a number of states or conditions with varying degrees of risk. The world was in a much more dangerous state in October 1962 during the Cuban Missile Crisis or in August 2008 during the Georgian war than it is as I write this. Similarly, many states of the world are possible after a nuclear weapon has been used in anger. A nuclear terrorist attack that destroyed Washington or Moscow or Tel Aviv would be horrendous, but produces an outcome very different from a full-scale nuclear war. The gap separating *The World As We Know It* super-state from the *Nuclear Disaster* super-state is called the nuclear threshold, and is crossed the first time a nuclear weapon is used in anger. Examples of states within the nuclear disaster super-state are:

<sup>2</sup> This use of the word “state” has no connection to political states (nations). Rather, it is similar to water having three states or conditions. Ice is the solid state, water is the liquid state, and steam is the gaseous state.

- a nuclear terrorist attack;
- a nuclear war between India and Pakistan;
- the accidental launching of a single missile; and
- the use of tactical nuclear weapons in what was, up to then, a conventional conflict.

Only the final state in the nuclear disaster super-state is a full-scale nuclear war. While no one knows for sure what that state would look like – whether it would throw humanity back to a dark age, end civilization, or end all human life on the planet – prudence dictates assuming that it is a state of no return, as indicated by the lack of a return arrow to any of the previous states.

Breaking down a complete failure of nuclear deterrence (*WW3* in Figure 2) helps to illuminate how it could occur, as well as the danger of lesser, but still disastrous nuclear events. This more nuanced diagram is one way of depicting how risk analysis approaches catastrophic failures, by decomposing them into their constituent parts.

In a similar way, eliminating the nuclear threat will require a multistage process. Those who say that goal is impossible are right in one sense. It is impossible from our current state, indicated in Figure 2 by the lack of a direct path from our current state (somewhere in the middle of *The World As We Know It*) to the state marked *Acceptable Risk*. There is too much mistrust, too little understanding and too much violence to achieve nuclear abolition, world peace or any other claimed solution to the nuclear threat. However, it is possible to increase trust, reduce misunderstanding and reduce the level of violence. If that is done, the world will be in a new state from which new steps can be taken that are currently impossible.

Analogous to the negative nuclear threshold, I have defined a positive threshold as occurring when there are 1,000 nuclear weapons worldwide, including in storage. The world's current inventory numbers around 20,000 weapons, so crossing this threshold will require an immense 95% reduction. Unlike the nuclear threshold, which is fairly well defined<sup>3</sup>, the positive threshold is more subjective. In keeping with my “order of magnitude” approach to the problem<sup>4</sup>, I used

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<sup>3</sup> Even the nuclear threshold has definitional problems. Would the use of a “dirty bomb,” with no nuclear explosive yield, but significant radioactivity dispersed, count? What about a primitive nuclear weapon with “only” the power of 100 tons of TNT?

<sup>4</sup> In engineering and science, an order of magnitude approach only deals with powers of 10, such as 1, 10, 100, etc. Numbers are rounded to their nearest power of 10. For example, 200 would be rounded to 100.

1,000 weapons as the threshold. This still allows nuclear deterrence in its current form, for example 300 weapons for the U.S., 300 for Russia, and 400 for the rest of the world. Those numbers would be more than adequate to deter any rational adversary and no number will deter an irrational one. While it is highly unlikely to occur from our current state, either the U.S. or Russia could therefore reduce its nuclear arsenal with little to no loss in national security, even if the other side did not immediately reciprocate. In light of the growing specter of nuclear terrorism, a reduced nuclear arsenal could even enhance national security by lessening the chance for theft or illicit sale of a weapon.<sup>5</sup>

The conditions needed to achieve such a 95% reduction in the world's arsenals would make the world much safer than it is today, but still would leave the potential for unimaginable horror if a misunderstanding or accident caused us to cross the nuclear threshold. And, as indicated by the paths crossing that threshold in both directions, it is reversible since we could rebuild our arsenals back above the 1,000 level. Even so, it would take a dramatic change in human thinking to achieve a 95% reduction. For that reason, I call the positive super-state, *New Thinking*. This is related to Albert Einstein's famous quote, uttered soon after the horror of Hiroshima and Nagasaki: "The unleashed power of the atom has changed everything save our modes of thinking and we thus drift toward unparalleled catastrophe."

If we can shift to the new thinking required to accomplish those reductions, new possibilities, currently inconceivable, would come into clearer view. Similar processes resulted in ending slavery and women's suffrage, both of which were discounted as impossible just decades before they occurred.

I have endured some criticism for worrying about full-scale nuclear war when nuclear terrorism is a more imminent danger. The above diagram and the related risk-based approach that I advocate, explain why that criticism is unwarranted. If we only studied the risk of nuclear terrorism, and the risk of nuclear war was also unacceptable, we would be doing nothing about the latter unacceptable risk. However, as shown in Figure 2, studying the risk of a full-scale nuclear war also requires studying the risk of events that could cause the nuclear threshold to be crossed, including a nuclear terrorist attack. If the risk of a full-scale nuclear war is found to be

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<sup>5</sup> These sentences were taken almost verbatim from a [summary statement](#) advocating applying risk analysis to nuclear deterrence that was signed by, among others, Adm. Bobby R. Inman. Inman was nominated by President Clinton to be Secretary of Defense, but withdrew his name from consideration when a nasty confirmation process was threatened. He also was Director of the National Security Agency and Deputy Director of Central Intelligence.

acceptable then – but only then – would it be prudent to restrict our attention to terrorism. Studying the risk of a full-scale nuclear war provides a system-level view, whereas studying only the risk of nuclear terrorism does not.

### **How likely is nuclear terrorism?**

Osama bin Laden has made no secret of his desire to obtain nuclear weapons and [kill millions of Americans](#). This threat is more serious than most people realize because the main obstacle to making a bomb is getting the nuclear fuel, and that is not always as well guarded as it should be. Under apartheid, South Africa developed a small nuclear arsenal that it dismantled as that regime was ending. The highly enriched uranium (HEU) fuel from about a dozen bombs is stored in their Pelindaba facility, which was successfully [attacked and entered](#) by armed men in November 2007. While it reportedly took security almost an hour to arrive and scare them off, fortunately they did not obtain any HEU. We may not be as lucky next time, and all it takes is once. If you haven't already watched the 13 minute [video interview](#) with the survivors of that attack, please do so now. It was part of the required reading (or watching) in handout #1, and conveys the risk of nuclear terrorism more powerfully than anything else I've seen.

In light of such information, it should not be surprising that former Secretary of Defense William Perry has quoted the odds of a nuclear terrorist attack within the next ten years as roughly 50-50. Republican Senator Richard Lugar conducted [a survey](#) of 85 national security experts that reached a similarly alarming conclusion. (See pages 14-15 of that document for the relevant data.) In *Nuclear Tipping Point*, former Secretary of State and former National Security Advisor Henry Kissinger states that “If the existing nuclear countries cannot develop some restraints among themselves – in other words, if nothing fundamental changes, then I would expect that the use of nuclear weapons in some 10-year period is very possible.”

Matthew Bunn's MIT thesis, [Guardians at the Gates of Hell](#): provides additional reasons for concern, for example:

Al Qaeda has ... explicitly set inflicting the maximum possible level of damage on the United States and its allies as one of their organizational goals. Intercepted al Qaeda communications reportedly have referred to inflicting a "Hiroshima" on the United States. Al Qaeda's spokesman, Sulaiman Abu Ghaith, has argued that the group "has the right to kill 4 million Americans -- 2 million of them children," in retaliation for the deaths the group believes the United States and Israel have inflicted on Muslims. Bin

Laden sought and received a religious ruling (fatwa) from an extreme Saudi cleric in May 2003 authorizing the use of weapons of mass destruction to kill American civilians [page 38]

The al Qaeda terrorist network and elements of the global network it has spawned have made repeated attempts to get nuclear bombs or weapons-usable nuclear materials to make them, and they have repeatedly tried to recruit nuclear weapons scientists to help them [page 15]

Osama bin Laden has made his desire for nuclear weapons clear in public statements. Al Qaeda launched a focused effort to get such weapons ... long before the 9/11 attacks, and this effort has continued [page 20]

terrorist teams [have been] carrying out reconnaissance at nuclear weapon storage sites and on nuclear weapons transport trains in Russia, whose locations and schedules are [supposed to be] state secrets; [There have also been] reports that the 41 heavily armed terrorists who seized hundreds of hostages at a theater in Moscow in October 2002 considered seizing the Kurchatov Institute, a site with enough highly enriched uranium (HEU) for dozens of nuclear weapons ... Aum Shinrikyo, the Japanese doomsday cult [responsible for the 1995 poison gas attack on the Tokyo subways which killed 12 and injured over 1,000] ... reportedly recruited staff members at the Kurchatov Institute [page 36 and 44-45]

While the threat of nuclear terrorism is often viewed as independent from that of nuclear war, there are at least two important areas of interaction. First, large arsenals assembled for fighting a nuclear war make it more likely that terrorists will get their hands on one. While most Americans worry primarily about “loose nukes” in the former Soviet Union, we also need to pay greater attention to laxity in our own procedures. The US Air Force [lost six nuclear warheads](#) in August 2007, when a B-52, supposedly loaded with twelve cruise missiles with dummy warheads, flew from Minot AFB in North Dakota to Barksdale AFB in Louisiana. After a day and a half it was discovered that six of the twelve warheads were real – a major error. Until that mistake was uncovered, these six nuclear weapons were inadequately protected from theft by terrorists and others intent on obtaining such a prize. It’s hard to keep track of 10,000 nuclear weapons (the approximate size of the American arsenal), making the terrorists job easier.

Another connection between nuclear terrorism and nuclear war is the danger that a nuclear terrorist incident could act as the catalyst for starting a nuclear war. This idea was treated fictionally in Tom Clancy's *The Sum of All Fears*, but also has a factual basis as detailed by CISAC's Dr. Pavel Podvig in a [2006 blog post](#):

[Is it possible that] Russia would believe, if only for a brief moment, that the United States might attack it? Normally, the answer is no. After all, the cold war has been long over and there has been no shortage of declarations of partnership between Russia and the United States. However, we should not overestimate the ability of the militaries to change and to adjust their operational practices and plans to the new realities. The strategic weapon systems that they operate were built with cold-war missions in mind and it is only natural that they impose cold-war thinking on their operators.

Here are some examples. One of the fighter pilots who was scrambled into the air on September 11, 2001 was reported to testify that: "I reverted to the Russian threat – I'm thinking cruise missile threat from the sea. You know, you look down and see the Pentagon burning and I thought the bastards snuck one by us."

If on September 10, 2001 someone would suggest that a U.S. pilot would assume that Russia might attack the United States, that person would have been laughed out of the room. But this is exactly what happened. Two more "coincidences" of that day – NORAD was scheduled to conduct an exercise, known as Vigilant Guardian, "which postulated a bomber attack from the former Soviet Union" (look for Note 116 in the 9-11 Commission Report), while Russian strategic bombers were indeed conducting an exercise that involved flights in the direction of the United States. As far as we know, NORAD never began the exercise that day and the Russian military grounded the bombers as soon as they learned about the events in the United States, but the number of coincidences is quite alarming.

Not that there are any signs that the military on both sides have changed their plans and no longer practice attacking each other. Just recently Russia conducted a large-scale exercise of its strategic bombers, in which they got close enough to the United States to be intercepted by NORAD fighter planes. The United States also routinely conduct exercises that involve a nuclear exchange with Russia.

On a more optimistic note, David Albright, a former weapons inspector in Iraq, puts the odds of a nuclear terrorist attack at less than 1%, but notes, "We would never accept a situation where the

chance of a major nuclear accident like Chernobyl would be anywhere near 1 percent ... A nuclear terrorism attack is a low-probability event, but we can't live in a world where it's anything but 'extremely low-probability.'" [[Hegland 2005](#)].<sup>6</sup> The in-depth risk analyses I [have proposed](#) would help reduce the uncertainty in these estimates.

### **How likely is nuclear proliferation?**

The United States became the charter member of the “nuclear club” when it tested an atomic bomb at Alamogordo, New Mexico on July 16, 1945. It cemented its status as the world’s sole superpower the next month when it used these weapons on Hiroshima and Nagasaki. Not willing to live in the shadow of an all-powerful America, the Soviet Union accelerated its own nuclear program and conducted a successful test in 1949. The United Kingdom and France, both eager to regain some of their former power, joined the club in 1952 and 1960 respectively. China, which had split with the Soviet Union and fought the United States in Korea, conducted its first test in 1964. India, which had fought a border war with China in 1962, joined in 1974. That led Pakistani Prime Minister Zulfikar Ali Bhutto to declare that, if need be, Pakistanis would “eat grass” in order to acquire their own bomb.<sup>7</sup> Pakistan conducted a successful test in 1998. North Korea, after initially ceasing its nuclear weapons program under the 1994 Agreed Framework, restarted that effort in 2002<sup>8</sup>, and conducted its first nuclear test in 2006.

Israel, while not a declared nuclear weapons state, is [estimated to have](#) approximately 70 warheads. [South Africa](#) was also an undeclared nuclear weapons state, but as the apartheid government prepared for majority rule, signed the Nuclear Nonproliferation Treaty (NPT) in 1991 and dismantled all of its nuclear weapons. This is one of the most stunning success stories in nonproliferation history. Unfortunately, we are currently facing a possible proliferation

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<sup>6</sup> That article quotes the odds at 1%, without reference to any specific time frame. Since earlier statements in the article concerned a ten year time frame, I assume that is what Albright also meant. However, it is important to note that many people use the wrong units in talking about the probability of a nuclear disaster – be it terrorism or war. The correct units are percent per year, not just percent. Even a 1% chance per year builds up to a much larger value over a number of years.

<sup>7</sup> The United States originally pressured Pakistan not to pursue a nuclear weapons program. But, following the Soviet invasion of Afghanistan in 1979, America put non-proliferation concerns on hold because Pakistan played a key role in funneling supplies to the mujahideen (including what became al Qaeda). A [Congressional research report](#) provides more details in its section on “Alternating U.S. Policy Priorities Towards Pakistan.”

<sup>8</sup> As we will cover later, there is strong evidence that, if the United States had not taken certain actions in 2002, North Korea probably would not have the bomb today. That statement was made by former Los Alamos Director and now Stanford Professor Siegfried Hecker in this seminar in the Winter of 2010.

avalanche. In addition to Japan and South Korea's concerns over North Korea's nuclear weapons, Iran appears to be on a course to become, at a minimum, a virtual nuclear weapons state – meaning that it would have the ability to create nuclear weapons in short order should it decide that was in its vital interests. A nuclear Iran would put immense pressure on the nonproliferation regime throughout the Middle East.

There is also significant danger in the large number of nations that have commercial nuclear power reactors, and in the predicted renaissance of nuclear power to reduce emissions of greenhouse gases. This problem was highlighted in [an essay](#) by Dr. Theodore Taylor<sup>9</sup> that appeared in a book I co-edited with Anatoly Gromyko back in 1987. Taylor wrote:

Deterrence, the cornerstone of national security in present strategies, fails against nuclear terrorism simply because there are no well- defined targets against which to retaliate. ... Even where there is no current diversion of nuclear materials, the worldwide spread of plutonium produced in civilian nuclear power reactors has produced “latent proliferation” — the ability to produce nuclear weapons in short order — in every country with a nuclear power plant. Nuclear explosives can be made with less than 6 kilograms of plutonium, in size about enough to fill a coffee cup. The world's present [1987] inventory of plutonium produced in civilian reactors is roughly 700,000 kilograms, greater than the total amount in the world's nuclear arsenals. This plutonium is being produced in thirty-six countries. By the year 2000, there will be more than 3 million kilograms of plutonium in the world, enough for at least 500,000 nuclear weapons.

In summary, nuclear proliferation is a serious issue that deserves much greater attention than it receives. It would also be wise to revisit past decisions, such as the one made by the United States after the Soviets invaded Afghanistan, that nuclear nonproliferation was less important than aiding the Pakistani-based *mujahideen* (known sometimes known as al Qaeda).

**How likely is nuclear war?** will be covered in the next handout.

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<sup>9</sup> Dr. Taylor was one of America's most brilliant nuclear weapons designers, and is the subject of John McPhee's book *The Curve of Binding Energy*. When we worked on his essay, he told me that he originally worked on these weapons in the belief that they made war impossible. During Viet Nam, the fallacy of his belief system became evident and he decided to try and “undo with the second half of my life what I had done with the first half.”