Assessing Global Catastrophic Risk

Seth D. Baum
Global Catastrophic Risk Institute

Published in *Sleepwalking to Armageddon: The 21st Century Threat of Nuclear Annihilation*, edited by Helen Caldicott, New York: The New Press, 2017, pages 3-10.

Imagine living here on Earth five billion years from now – toward the end of when it is physically possible to live on Earth. The Sun gradually gets warmer, and over billions of years, eventually it becomes too hot for life as we know it to survive here on Earth. But five billion years from now, humans might exist not only on Earth; we might have spread across the stars, forming an immense galactic civilization that dwarfs anything we could have on Earth.

What besides the sun could jeopardize the future of the human race? Because humans are currently confined to earth, major global catastrophes are events so severe that they could make the difference for that entire great, beautiful future of the species. A global catastrophe could ruin it all, depriving countless members of countless future generations the chance ever to live. So, will we succeed at avoiding catastrophe, so that this great, beautiful future can occur? Or will we fail, ruining it all?

When we talk about the catastrophic risk of nuclear war, the biggest thing that could be at stake is no less than the entire fate of human civilization.

* * *

We know that a single nuclear weapon can cause an enormous explosion. And we know that the explosion can cause great damage and kill many people. But a single nuclear explosion does not make for a major global catastrophe. It would kill many people, but it would leave the rest of human civilization intact.

In fact, the biggest risk from nuclear weapons is not the initial explosion itself, but the smoke from the firestorm, which would rise high up into the atmosphere and spread out all around the world. This smoke would block incoming sunlight, cooling the surface of the planet, and reducing precipitation. The resulting extreme environmental conditions would make it very difficult for plants to grow, including those we grow for our food.

Studies have shown that in a nuclear war scenario with 100 nuclear weapons, extreme environmental conditions could cause a famine in which two billion people are at risk of starvation. If two billion people die, this would obviously be an enormous catastrophe. But on its own, two billion people dying does not make for a major, permanent global catastrophe. After all, if two billion people die, there are still five billion people alive and able to carry humanity into the future. Needless to say, this doesn't mean that we shouldn't care about two billion people dying. Of course we should care. But, from the perspective of the entire fate of human civilization, two billion deaths might not matter all that much.

So what would matter? Would nuclear war cause the permanent collapse of global human civilization? Throughout human civilization, a number of great

civilizations have collapsed, some never to return. And some of these collapses were caused in part by environmental problems. However, none of these civilizations come anywhere close to the scale and sophistication of the modern global civilization we live in today. So it is very difficult to say whether a nuclear war would cause the collapse of global human civilization.

One thing we can say is that, the larger the nuclear war, the more likely a permanent collapse. If zero nuclear weapons are used and there is no nuclear war, there is no chance of permanent catastrophe. If all 16,000 nuclear weapons that exist in the world today are used, the probability of permanent catastrophe is high. Exactly how high is uncertain, but high enough for us to worry about. On the other hand, we can imagine a nuclear war that entailed, say, 30 or 40 nuclear weapons. If they're dropped on major cities, major nodes in the global economy, there would be large global economic and political consequences, but the environmental risks would probably be small. Indeed, at a threshold of about 50 nuclear weapons, the probability of permanent catastrophe from the environmental consequences is insignificantly low, so low that at that point we have more important things to worry about, including all the other catastrophic risks. There is still the chance of permanent catastrophe from the loss of major cities causing global economic failure. In this case, the threshold might be lower than 50 nuclear weapons, but it is still somewhere above zero.

Even if human civilization can survive into the distant future with 30 or 50 nuclear weapons, there are still plenty of good reasons to aim for a world with zero nuclear weapons. But the important thing is not the difference between zero and 50 nuclear weapons, but the difference between either of those and the 16,000 weapons in the world today. It is imperative both that these weapons not be used, and that their number be reduced down to a safe level, because these weapons pose a catastrophic risk to the species.

In addition to the assessing the impacts of nuclear war entailing different numbers of weapons, a complete treatment of risk also needs to look at the probability of nuclear war occurring. If the probability is zero, then there will be no nuclear war, and we don't have to worry about the consequences. And indeed, there are some people who would say that the probability basically is zero. After all, there have never been any nuclear wars before.

Well, that isn't quite true. There has been a nuclear war; World War II was a nuclear war. But it is true that there has never been a large nuclear war involving 50 or 16,000 nuclear weapons. However, the fact that no large nuclear war has ever happened before doesn't mean that the probability one will happen in the future is zero.

This is the same mistake that people in Britain made several centuries ago about black swans. They believed that black swans were impossible. They had never seen black swans before. To them, all swans were white. But there are black swans. They live in Australia. It is a mistake to believe something is impossible just because you've never seen it before.

There is an additional reason why this kind of thinking is a mistake with respect to nuclear war -- researchers call it the observation selection effect. We are selected to observe only those events that do not kill us. If a large enough nuclear war could kill us all, then we can observe it only in the brief moment when we are dying. The fact that you're alive today reading this book requires that no such large nuclear war has ever

occurred before. So it is that much more of a mistake to say that the probability is zero just because we've never seen it happen before.

So, what can we say?

One thing we can do is look at the history we have observed and learn what we can from that. For example, the Cuban missile crisis is perhaps the closest the world has ever come to nuclear war. Martin Hellman of Stanford University modeled the series of steps through which crises like the Cuban missile crisis could end in nuclear war. First is the relative calm before the crisis. Second is the initiating event, which in Cuba was the US discovery of Soviet nuclear weapons there. Third is the crisis itself. Fourth is the launch of a nuclear weapon. Finally, fifth is the escalation to full-scale nuclear war. The first three steps all occurred in the Cuban missile crisis. The fourth and fifth steps have not previously occurred but would need to occur for the crisis to end in nuclear war.

For each of the steps in the model, Hellman estimated the probability of its going on to the next step. For the first two probabilities, he used numbers based on observations from history. For the second two probabilities, he used a range of numbers. The steps have never happened before, so the probability of getting there is uncertain. Multiplying these numbers out gives a range of probabilities corresponding to about one of these nuclear wars occurring every 200 years to one per 5,000 years.

Once per 200 or 5,000 years might seem like a low probability, rare event. And it's true: This type of nuclear war is unlikely to happen this year, or next year, or the year after that. But the longer we wait, the further into the future we go, the more likely it is for one of these nuclear wars to occur. And it is highly improbable – basically impossible – that with weapon supplies remaining at their current levels, humanity could make it for billions of years into the distant future without one of these nuclear wars occurring. And this analysis is just for an intentional nuclear war.

Another type of nuclear war is called inadvertent nuclear war. Inadvertent nuclear war occurs when one side misinterprets a false alarm as a real nuclear attack and launches nuclear weapons in what it believes is a counterattack, but is in fact the first strike. Inadvertent nuclear war is important because it means we could end up in nuclear war even if deterrence works perfectly.

What is deterrence? Deterrence is threatening someone else with some sort of harm in order to convince them to not do something. In nuclear deterrence, both sides threaten each other with nuclear retaliation. Since neither side wants to be hit with that retaliation, neither side launches their nuclear weapons. It's a way of avoiding nuclear war. And deterrence works. However, it does not work perfectly. This is shown by a number of historical cases, including the Cuban missile crisis.

Even if deterrence did work perfectly, we could still end up in an inadvertent nuclear war. In the inadvertent nuclear war scenario, the other side actually was deterred. They had not launched nuclear weapons. But the one side thought they were under attack anyway, and we end up in nuclear war.

Over the years, there have been a number of close calls of inadvertent nuclear war. These are false alarms that were believed to be real nuclear attacks. Here are four of them:

- 9 November 1979: The United States' North American Aerospace Defense Command (NORAD) training tapes appeared to show a real Soviet strike.

- 3 June 1980: United States Strategic Air Command has a faulty computer chip showing Soviet missile launches.
- 26 September 1983: Sunlight reflects off clouds towards a Soviet monitoring satellite triggering an alarm. Soviet Air Defense Forces officer Stanislav Petrov refuses to treat the alarm as real.
- 2 November 1983: NATO began a large military exercise in western Europe. Some of the Soviet leadership believed the exercise was cover for a real attack, and in response the Soviets put their nuclear forces on alert.
- 25 January 1995: Russia detects a joint USA-Norway scientific rocket launch off Norway's coast, believing it to be a nuclear missile.

Fortunately, in each of these cases, no nuclear weapons were used. However, in the future, we might not be so fortunate.

My colleagues and I have studied the probability of inadvertent nuclear war between the United States and Russia using what's called a fault tree model. A fault tree branches out into different scenarios, each of which could be at fault for causing inadvertent nuclear war.

The leaves at the ends of the branches are two types of false alarms and two conditions in which the alarms can occur. One type of alarm is the "usual" alarms, which are the sorts of false alarms that have happened before, as discussed above. The other type is a nuclear terrorist attack misinterpreted as an attack by another country. The two conditions are crisis conditions between the two countries and conditions of relative calm. As you might imagine, countries are a lot more likely to believe they are actually under attack if they are in a crisis.

We modeled the series of steps going from the alarm, through the chain of command, to the ultimate decision to launch nuclear weapons in response. The chain of command goes from the military staff who monitor for false alarms, to their superiors, all the way up to the President, who makes the launch decision. For each step, we considered a range of probabilities for the alarm being passed to the next step. We also used a range for the probability of crisis between the countries. We used ranges because the exact numbers are uncertain.

Multiplying these out gives a range of results for the probability of US-Russia inadvertent nuclear war. We looked at two cases: if the war can happen at any time or if it can happen only during a crisis. We get wide ranges for each: once per 14 years to once per 5,000 years if it can happen at any time, and once per 20 years or once per 100,000 years if it can happen only during a crisis. The ranges are so wide because it is such an uncertain risk.

Despite the uncertainty, the numbers clearly show that this is a worrisome risk. The average probabilities are 50 and 100 years. Even with the low probabilities, once per 5,000 and 100,000 years, a catastrophe is likely to occur not too far into the distant future.

* * *

One thing we can see in the inadvertent nuclear war numbers is that the probability of inadvertent nuclear war is lower if it can happen only during crisis. This shows that we can reduce the risk by avoiding crisis. That means resolving the current conflict in Ukraine, which has increased tensions between the US and Russia. It means

making sure tensions over Taiwan never escalate between the US and China. And so on for other issues between other nuclear-armed countries.

Indeed, a core reason why it's important to analyze risks in so much detail is because, at every step along the way, we learn of opportunities to reduce the risks, and we get some understanding for how effective they would be.

So how do we get to the great, beautiful future that human civilization can enjoy without destroying it all with a major global catastrophe? The answer is, by understanding the risks and seizing the opportunities we have to reduce them. For the sake of the entire future of human civilization, we should make these activities a top priority.