

On the Inevitability and Prevention of Nuclear War

by Dr. Martin E. Hellman, *New York Epsilon '66*

The unleashed power of the atom has changed everything save our modes of thinking and we thus drift toward unparalleled catastrophe.
Albert Einstein

UTTERED soon after the horror of Hiroshima and Nagasaki, Einstein's prophesy (1) states the problem and, by implication, the solution. The problem: an old mode of thinking about war, weapons and security, developed over thousands of years but made obsolete by modern technology. The solution: a new mode of thinking based on the equations which govern survival in the nuclear age.

In the 40 years since Einstein's prophesy we have not changed our mode of thinking, we have continued to drift, and, as a consequence, we are perilously close to the unparalleled catastrophe he foresaw. Although many people point to science and technology as the villains in this drama, in reality it is the antithesis of the scientific spirit that has brought us to the edge of the cliff.

The scientific spirit is exemplified by a zealous search for the truth, a ruthless disregard for commonly held beliefs when they are contradicted by the observed data, and a willingness to risk stating what is unpopular but true. Shining examples include Copernicus, Galileo and Darwin.

The scientific method has been widely used in the engineering decisions involved in the development of weapons technology. But, to date, it has been little used in the political decisions involved in deciding what technology to develop. Economics, domestic politics, and outdated thinking have distorted our search for national security so that, paradoxically, we are less secure today than at any point in history (2). We could be destroyed in a matter of minutes.

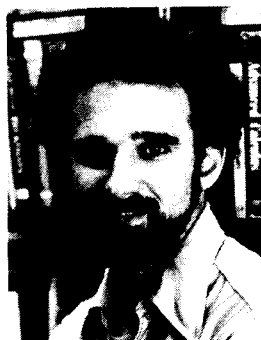
We must embrace the scientific spirit if our quest for national security is to prove successful. To do that we must deal with a base of reality, not illusion. Yet most people suffer from one or more of three common illusions:

1. Even if a nuclear war occurs, we will somehow survive.
2. Nuclear war is so horrible, no one would let it happen.
3. I, as an individual, cannot make a difference.

This paper uses the scientific method to examine and dispel each of these illusions. In the case of the second illusion it actually proves that, if we persist in our old mode of thinking, World War III is not just possible, it is inevitable.

This threat of inevitable unparalleled disaster carries with it an unparalleled opportunity. The proof that World War III is inevitable on our current path has a corollary: The only way to avoid extinction is to build a world in which war is totally unthinkable; a world in which hunger, overpopulation, ignorance, and the other root causes of war are eliminated. Technology, which gave us the ability to destroy civilization, also gave us the opportunity to build such a world. We are forced to choose between using our technology for the ultimate war or for the ultimate peace.

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How Bad Would It Be?

THE first illusion is that we would survive World War III much as we survived the first two World Wars. While no one knows exactly what would happen in an all-out nuclear war, there is overwhelming evidence that World War III would be of a totally different character from anything in our past experience.

World War II took place over six years and killed approximately 50 million people — air raids on Hamburg, Dresden, Coventry, and Tokyo; the battles of Normandy, Anzio, Leningrad, and Okinawa; and the atomic bombing of Hiroshima and Nagasaki. Yet, all of that pales by comparison with the destructive potential of World War III.

The combined firepower of all the weapons used in World War II, including the two atomic bombs dropped on Japan, was approximately three million tons of TNT — three megatons (3). The current firepower in the nuclear arsenals of the superpowers is approximately 18,000 megatons — equivalent in destructive power to 6,000 World War II's.

While we cannot accurately predict the exact level of destruction inherent in a third World War, there is strong evidence that current assessments underestimate the devastation. This evidence is in the form of disastrous side effects of nuclear explosions which have been discovered largely by accident: for example, the strong electromagnetic pulse (EMP) emitted by a nuclear blast and its debilitating effect on command and control electronic equipment (4), or the threat nuclear weapons pose to all life through possible destruction of the earth's ozone layer (4).

The most recent unforeseen side effect is the possibility of a "nuclear winter" (4, 5, 6, 7). If enough nuclear weapons are exploded in a short period of time, dust from the nuclear explosions and smoke from resultant fires would blanket the earth. The dust and smoke would black out the sun, lowering temperatures, and plunging the earth into a global nuclear winter. Photosynthesis would cease for months. In the resultant, unimaginable ecological collapse, life might well disappear from the face of the earth (4, 6, 7).

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The evidence strongly supports the hypothesis that we have reached the point where another world war would mean the end of civilization. While arguments which question some aspects of this evidence have been advanced and further research is needed to resolve those questions, our profession tells us how to act. When dealing with uncertain systems where lives are at stake, good engineering practice demands that we design conservatively, allowing generous safety margins and using worst case assumptions. So, our professionalism requires that we base our actions on the hypothesis that global war has become a path with no return.

This asymmetry can be depicted by a two-state model. As shown in Figure 1, we classify the world as being in one of two possible states, a state of *GLOBAL WAR* and a state of *ARMED DEFENSE*. By definition, this latter state includes limited war and all other substates the world has experienced short of global war.

Prior to World War I, the world had only been in the state of *ARMED DEFENSE*. In 1914, when the first global war commenced, a transition was made to the state of *GLOBAL WAR*. The world stayed there for four years until World War I ended in 1918, at which time a transition was made back to the state of *ARMED DEFENSE*. Similarly, two transitions were made in 1939 and 1945 when World War II started and stopped. The fact that transitions were possible in both directions is indicated by the bidirectional arrows of Figure 1.

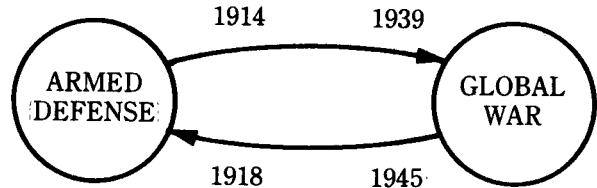


Figure 1: Pre-Nuclear Model of the World.

However, the unleashed power of the atom changed both the diagram and the world in a fundamental way. It is still possible to make a transition into the *GLOBAL WAR* state. But as shown above, we must now base our actions on the hypothesis that *GLOBAL WAR* has become a state of no return. In the parlance of Markov chains, the state of *GLOBAL WAR* has become an "absorbing state," a one-way street, as shown in Figure 2.



Figure 2: Post-Nuclear Model of the World.

Inevitability

WE now turn to the second illusion: Because *GLOBAL WAR* has become a one-way street, most people believe it will not happen, that no one in his right mind would even consider starting it. But that is demonstrably false (8). President Truman threatened to use nuclear weapons in 1946 against the Soviet Union's continued occupation of Iran, in 1948 during the Berlin crisis, and in 1950 in Korea. President Eisenhower threatened their use in 1953 in Korea, in 1954 in Viet Nam, and in 1958 in both the Middle East and China. President Kennedy considered the use of nuclear weapons in 1961 during another Berlin crisis. And, in 1962, the Cuban missile crisis was a near hit. Presidents Johnson and Nixon both considered the use of nuclear weapons in Viet Nam. In what is now known as the "Carter Doctrine," President Carter threatened to use "any means necessary" to halt possible Soviet expansion into the Persian Gulf region. President Reagan reaffirmed the United States' commitment to this doctrine. While these American threats are well documented, it is highly probable that the leaders of the Soviet Union and the other nuclear powers have also been tempted to consider using nuclear weapons when faced with similar political problems.

These threats establish the possibility of nuclear war, but our prognosis is actually much bleaker. No matter how small the probability of transition into the state of *GLOBAL WAR* is, so long as it stays bigger than zero, ending up in the *GLOBAL WAR* state is *inevitable*. Continual use of deterrence or of any other strategy that has a chance for accident or miscalculation guarantees the destruction of civilization.

On our current path, World War III is not just a possibility. It is a mathematical certainty.

This inevitability can best be understood by first considering a hypothetical, suicidal "game": Toss a coin until it shows a Head for the first time. Then you are shot. If you play this insane game continually, you are guaranteed to die. The coin will eventually show a Head.

The state diagram for this game, shown in Figure 3, is identical to the state diagram for the post-nuclear world shown in Figure 2. Only the names of the states and the value of the transition probability are different.

In this game the probability of being shot within n trials or tosses is $1 - (0.5)^n$, so there is a 50 percent chance of being killed on the first trial; there is a 75 percent chance of being killed by the second trial; and there is a 99.9999 percent chance of being shot within the first 20 trials. Because the chance of being shot is one in two at each trial, you expect to be killed on the second trial. But even if you are lucky enough to be alive at trial 20, if you keep playing, you are inevitably shot. Mathematically, it is said that you are shot "with probability one."

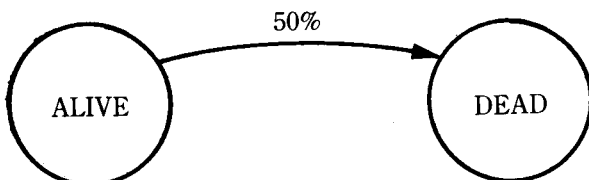


Figure 3: The State Diagram for a Suicidal Game.

If you play the same game, but reduce the chance of being shot at each trial from 50 percent to one chance in six (16.7 percent), you still die with probability one. This version of the game, in which the probability of death is one in six at each trial, is known to us (but not the Russians) as Russian roulette.

A revolver with six chambers is emptied, and one chamber is reloaded with a bullet. The cylinder is spun, the gun is put to your head, and the trigger is pulled. It is insane

to play this game even once, and it is certain suicide to play continually. Because the probability of being shot at each trial is one in six, you expect to be shot on the sixth trial. But if you survive six, or even sixty, trials, if you keep playing, you are inevitably shot.

The probability of being shot within n trials is now $1 - (5/6)^n$. So on the first pull of the trigger, the probability of being shot is 16.7 percent; within the first six pulls of the trigger, it is 66.5 percent; within the first 20 trials, 97.4 percent; and the chance of being shot within the first 100 trials is 99.99999 percent. Compared to the game where there was a 50 percent chance of being shot at each trial, you prolong your agony, but you still are certain to be killed.

It does not matter whether the probability is one in two, one in six, one in six hundred, or whether the probability varies with time. Low probability risks build up over time to probability one. No matter how small the probability of being shot at each trial, continually pulling the trigger results in certain death.

No sane person would play Russian roulette even once. Yet we are continually playing nuclear roulette, a version of Russian roulette in which the entire world is at stake. We have pulled the trigger in this macabre game more often than is imagined. Each action in our old mode of thinking has some chance of triggering the final global war; each "small" war — in Iran, Iraq, Viet Nam, Afghanistan, or the Falklands — is pulling the trigger; each threat of the use of violence — as in the Cuban missile crisis — is pulling the trigger; and each day that goes by in which a missile or computer can fail is pulling the trigger.

Even if we shifted to a new, lower-risk strategy, we would not survive in the long run. If we continue taking low probability risks, the chance of World War III is not low. It is certain. The probability builds up over time.

The only way to survive Russian roulette is to stop playing. The only way to survive nuclear roulette is to move beyond war as depicted in Figure 4. We must add a third possible state, a *WORLD BEYOND WAR*, that has never existed before. This new state is also an absorbing state because, in it, we have made a *total* decision to cut away from war as a possibility, so neither of the two previously possible states is reachable. To reach this state we must register the reality of our nuclear environment, decide to change our mode of thinking based on that reality, and then act on the truth that, today, war — nuclear war, conventional war, or even the preparation for war — leads inevitably to extinction.

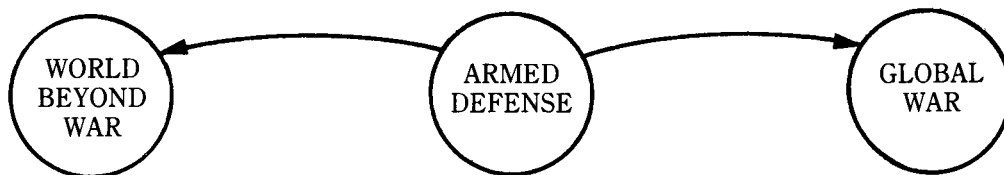


Figure 4: A Three-State Model Allows Survival.

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Possibility

THE above proof of the inevitability of nuclear war has a profound corollary: Moving beyond war is our only survival strategy in the nuclear age. But is a world beyond war possible? That question has two parts, technological and human: "Do we have the technology to end war?" and "Are we willing to use it?"

The answer to the first question is a resounding "yes." In a coincidence of cosmic proportions, the technology required for the ultimate peace has evolved at the same time as has the technology required for the ultimate war. Technology has presented us with the nuclear ultimatum, but it also has provided us with the opportunity to eliminate hunger, over-population, and other root causes of war; it has given us inexpensive mass communications to reach into every corner of the globe; it has given us satellites and seismic detectors that can verify compliance with arms control treaties; it has given us insight into the mischievous workings of our own psyches; and it has given us the ability to travel around the world to gain direct information about other nations and cultures.

Technology has given us the means to end war or to end life. So the question is not whether war can be eliminated. It can. The real question has to do with our capacity as human beings: Can we extend ourselves and realize a nobility of spirit that has eluded us in the past?

Given the magnitude and inevitability of the nuclear threat, given the strides in the technologies required for peace, and given the recent, rapid advances in humanity — the abolishment of slavery, equality of women's rights, and advancement of human rights — I firmly believe we are capable of making that great an advance. But I cannot guarantee or prove it.

While it cannot be proved that humans have the capacity to move beyond war and thus survive in the nuclear age, the only logical choice is to assume it as a working hypothesis: If we assume we are not capable of growth and survival, we will not survive even if we are capable of it. Whereas, if we assume we are capable, we have a chance for survival. There is nothing to be lost and everything to be gained by assuming the nobler hypothesis.

Conclusion

THERE is potential for this to be either the best of times or the end of time, depending on which direction we take at this critical juncture in human evolution. Technology has given a new, global meaning to the Biblical injunction, "I have set before you life and death, blessing and curse; therefore choose life, that you and your descendants may live." (9) To avoid extinction, we must take action to shift from an old mode of thinking, which justifies war as necessary for survival, to a new mode of thinking, which recognizes war as the ultimate threat to survival.

There is no shortage of good proposals to serve as possible first steps out of our current dilemma. The real barrier to solving this problem is our old mode of thinking, reinforced by the illusions discussed in this paper. That thinking prevents us from really experimenting with any of these proposals because it perpetuates the myth that there is another way out. It is the source of what Einstein called our "drift toward unparalleled catastrophe." We are in a new era. And, to survive, we must break out of the mindset of the past.

Each individual in society bears the responsibility for examining his own thinking on weapons, war, and security, and realigning it with the new data of the atomic age. We, as scientists and engineers, bear an even greater responsibility, because that process is the scientific spirit to which we have dedicated our lives and because much of the population looks to us to solve this problem with some kind of gadget. We must state clearly that people cannot look to gadgets for salvation, that technology has provided all that it can, and that the solution now lies within each individual — in our ability to shift our own mode of thinking and then to communicate the need for the shift to others.

Few people understand the full magnitude of the threat. Even fewer understand that new technology, new politicians, or new laws, by themselves, will not remove the threat. Those who do understand are desperately needed to speak out clearly, forcefully, and in a spirit of goodwill. Only then will an environment be created in which the required societal change can begin. And only then will we ensure a meaningful future for the generations to come.

You will say at once that, although the abolition of war has been the dream of man for centuries, every proposition to that end has been promptly discarded as impossible and fantastic. But that was before the science of the past decade made mass destruction a reality. The argument then was (only) along spiritual and moral lines, and lost. But now the tremendous evolution of nuclear and other potentials of destruction has suddenly taken the problem away from its primary consideration as a moral and spiritual question and brought it abreast of scientific realism.

— General Douglas MacArthur
Address to Philippine Congress, 1961.

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