The Technological Imperative for Ethical Evolution[1]

Prof. Martin E. Hellman, Stanford University

Introduction

Almost overnight, the Manhattan Project transformed ethical decision making from a purely moral concern into one that is essential for the survival of civilization. In the words of Albert Einstein, "The unleashed power of the atom has changed everything save our modes of thinking and we thus drift toward unparalleled catastrophe." [Nathan and Norden 1981]

Environmental crises such as climate change, along with recent technological breakthroughs in genetic engineering, AI, and cyber-technology are adding to the technological imperative for accelerating humanity's ethical evolution.

This paper presents eight lessons for accelerating that process, often using examples where I either failed to behave ethically or encountered great difficulty in doing so. I hope it thereby adds, however meagerly, to humanity's odds of avoiding Einstein's "unparalleled catastrophe" and, instead, building a world that we can be proud to pass on to future generations. No one person can solve this problem, but if enough of us move things a little, all together we can succeed.

Lesson #1: It's easy to fool ourselves

In March 1975, the US National Bureau of Standards (NBS, now renamed NIST for National Institute of Standards and Technology) published a proposed national Data Encryption Standard or DES [NBS 1977]. Up to that time, encryption had been the almost exclusive preserve of the military and diplomatic communities, with only minor interest from commercial entities. But the growing relationship of computers and communications—they had not yet been "married" into the Internet—was visible on the horizon.

My colleague Whit Diffie and I were among a small group peering into that future and we devoured the DES publication. A glaring deficiency soon became obvious. While DES claimed to have a 64-bit key, 8 of those bits were inactive so there it really only had a 56-bit key. That meant it had only around 100,000 million million keys. We estimated that a special purpose, massively parallel computer could search that seemingly huge key space in about a day and at a cost of roughly US$10,000 per solution.

We proposed that a specially designed LSI chip could search a million keys per second, even with 1975's technology. At roughly US$10 per chip, a million of them would cost US$10 million and would take only 100,000 seconds—a little more than a day—to search the 100,000 million million keys. [Diffie and Hellman 1977]

Thinking that this was a bug, we alerted NBS and expected it to remedy this error, especially since increasing DES's key size was both easy and cheap. We were surprised when NBS told us that it did not see a problem. Their June 27, 1975 letter never specifically dealt with our objection to the small key size, but spoke to it tangentially:

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[1] This paper is a more detailed, written version of an address given on July 3, 2019 at the Lindau Meeting of Nobel Laureates. Portions are adapted from Dorothie and Martin Hellman, *A New Map for Relationships: Creating True Love at Home & Peace on the Planet*. Reprinted with permission. A PDF is freely available online.

> We feel that the selected algorithm does fulfill the requirements for data protection in organizations which do not have other means of cryptographic protection available to them. In making this. determination, the threats to sensitive and valuable computer data were postulated for various applications and then compared with the costs of combating those threats. … The algorithm, when used properly by computer users, will provide protection beyond the normal life cycle of the data and the data processing equipment.

After several more iterations of letter writing and refining our estimate, it became clear that what we had seen as a bug was, in fact, a feature—from NSA's perspective. The American National Security Agency is estimated to have an annual budget of approximately US$10 billion ($1E10), and spends much of that money on communications intelligence: vacuuming up large amounts of computer readable data and "bagging" the small amount of interesting traffic. In 1975, almost all such data was unencrypted, so DES threatened to choke off a valuable national security resource. Apparently, a 56-bit key size was deemed a not insurmountable obstacle to such continued NSA operations, but 64 bits would be.

If we wanted to improve the security of DES, we had to stop treating it as a technical problem and treat it as the political problem that we now knew it was. We had to get media coverage and Congress' attention. In January 1976, as we set out to do that, two high level NSA employees paid us a visit and warned us that continuing on our current path would "cause grave harm to national security."

After their visit I sat down to figure out the ethical thing to do. On the one hand, I had NSA saying that going public would be a disaster for my country. On the other hand, I could foresee the coming computer-communications revolution. Keeping quiet would expose people's confidential information to prying eyes, including our own government's. This was 1976, just a few years after Watergate, so trusting the government seemed questionable.

As I was trying to decide the right thing to do, an idea popped into my head: "Forget about what's right and wrong. You have a tiger by the tail. Run with it!" I felt like I was in a movie with a devil sitting on my shoulder, whispering in my ear. At the time, I thought I brushed the devil off my shoulder, and made a rational decision to go public with DES's inadequate key size. But five years later, in the summer of 1981, I realized I had fooled myself. How did that happen?

My wife Dorothie and I were in the process of repairing our marriage, which after 14 years was a wreck. A year earlier, before I understood how much trouble we were in as a couple, Dorothie had dragged me to meetings of a group that she felt could help us. But now, a year later, I was starting to clean the filter through which I viewed the world. I was opening up to ideas that previously I would have rejected because they were outside my frame of reference.

We were at a week long seminar run by the group—something I never would have "wasted" time on before—and, as part of that experience, we watched a documentary about the making of the atomic bomb. The first test explosion was codenamed Trinity, and the documentary was called *The Day After Trinity*.

An interviewer asked each of the Manhattan Project scientists about their motivation for working on this weapon of mass destruction that killed well over 100,000 people at Hiroshima and Nagasaki.

To a man—and they all were men—they answered the same. Fission had been discovered in Germany, and we had to get the bomb before the Nazis did. When responding to this question,

Robert Wilson, who later became the first Director of Fermilab, became highly animated, reliving the exhilaration he felt when he joined the project:

> It was a time that the whole country was pulling together in a cause, which even now I think was just. … [If] the Nazis … would win that war [it] could have led to … a thousand years of dark ages, and everything that we meant by civilization could have come to an end. That's what it seemed to me was what the fight was about.

Later in the documentary, the interviewer asks each of the scientists another question. When the Nazis surrendered in May 1945 and the scientists' stated motivation for working on the bomb was gone, why did they continue? In answering this question, their demeanors change markedly. They become quiet, even defensive. Wilson, puzzled by his lack of introspection, was surprisingly honest:

> I would like to think now that at the time of the German defeat that I would have stopped, taken stock, thought it all over very carefully, and that I would have walked away from Los Alamos at that time. And in terms of everything that I believed in, before and during and after the war—I cannot understand why I did not take that [action]. On the other hand, it simply was not in the air. … Our life was directed to do one thing. It was as though we had been programmed to do that, and we as automatons were doing it.

When Wilson heard that the bomb had been dropped on Hiroshima, the horror of what he had done hit him. He was overcome with nausea and vomited.

Watching the video took me back five years, to January 1976, when I thought I had brushed the "devil off my shoulder" and made a rational decision to go public about DES's inadequate key size. With the new insights that I had developed over the previous year of working on my marriage, I could see why the Manhattan Project scientists might have continued working on the bomb after the Nazis were defeated: In addition to their stated, socially acceptable motivation, they had unstated, socially unacceptable motivations that were hidden not only from others, but even from their own conscious minds. I can't be sure what they were for those men, but putting myself in their shoes, I might have wondered: "Could I, the nerd who got picked on by the other boys, become a war hero? Is my brain powerful enough to destroy a city?" And more.

That's why I believe they were so puzzled. Given the consequences of their actions—roughly 200,000 men, women, and children killed, many suffering before being blessed with death—their unstated motivations were so despicable that they were not allowed to rise to consciousness.

The Day After Trinity got me to see how I had deceived myself in a very similar way. I thought I had brushed the devil off my shoulder, but I had only submerged him back into my unconscious self from which he had emerged. In that murky deep place, he was free to work his mischief without my conscious mind being disturbed that I might be causing "grave harm to national security" just to be famous.

Like the Manhattan Project's scientists, I had fooled myself. Instead of doing what was ethical, I had figured out what I wanted to do and then came up with the rationalization for doing it.

I was fortunate that my decision was the right one, the same one I would have made had I made it ethically. I can be sure of that because Adm. Bobby Inman, the Director of NSA at that time, later said so. When asked if he now would make the same decision as he did forty years

ago to try to suppress our work, he replied, “Rather than being careful to make sure they [weren’t] going to damage [NSA’s intelligence operations] … I would have been interested in how quickly they were going to be able to make [encryption widely] available.” He cited the theft of portions of the F-35 jet fighter design as proof that strong commercial encryption was in the nation’s broader national security interests

It was sheer luck that fooling myself still led to the right decision, the ethical one. But, if I had been working on the Manhattan Project, I could have done the same thing as those scientists with serious consequences. I vowed never to fool myself again, but that was easier said than done as can be seen from the next, related story in lesson #2.

Lesson #2: The value of outside help

Soon after Whit and I took on NSA over DES’s inadequate key size, he and I, along with another of my students (Ralph Merkle) invented a new kind of cryptographic algorithm—public key cryptography—that revolutionized the field. Today, that technology secures all of your electronic banking and your Internet credit card purchases. It also secures $5 trillion a day in foreign exchange transactions, so even a tiny royalty would make us millionaires many times over.

Unfortunately, our patents didn’t make the three of us wealthy. While there were several reasons, one of them was a patent fight with a company, RSA Data Security, founded by three of my colleagues at MIT, who had come up with their own way of doing what we had proposed.

In the paper describing their approach, they credited my group with inventing public key cryptography. But, when we asked them to pay royalties, they said that our patents were invalid. When we persisted, they told us to sue them. This was probably a bluff since, at the time, RSA didn’t have the kind of money needed for a patent fight. But neither did we.

Stanford University owned our patents, with each of the three inventors getting roughly 10% of whatever Stanford took in. So Stanford would be the one to sue RSA and foot the legal bill. I’ll never forget the meeting with Stanford’s outside patent counsel, where he warned the university not to get started with litigation unless it could give him at least a quarter of a million dollar budget—the equivalent of well over US$1 million today. Stanford decided not to risk that kind of money on a technology that almost no one had yet licensed, allowing RSA’s bluff to win and creating a dangerous precedent for the legal fight that eventually took place.

Several years later, the CEO of a Silicon Valley startup, Cylink, approached me, trying to get an exclusive license to Stanford’s patents. Lew Morris was a scrappy little guy from Philadelphia who reminded me of the kids I’d grown up with in the Bronx. His language did too: “Help me get an exclusive license from Stanford, and I promise you, we’ll get those RSA bastards by their balls.”

This was after Dorothie and I had committed to living our lives ethically. So I should work with Cylink only if it made good business sense, not out of a desire for revenge.

As I thought it through, it seemed clear to me that working with Cylink made good business sense. But, I was so mad at RSA that I couldn’t be sure I wasn’t fooling myself—something I’d vowed never to do again. Whenever you’re that emotionally involved in a fight, it’s impossible to be sure that you’re being objective.

I went to Dorothie, told her my conundrum, and asked for her advice. She asked me if Nils Reimers, Stanford's Director of Technology Licensing had the kind of emotional involvement in this fight that I did. He didn't. Dorothie then asked if Nils and I had the same business interests, which we clearly did. Dorothie then suggested that I let Nils make the decision. Clouded by my emotions, that simple, brilliant solution had eluded me.

I set up a meeting with Nils, explained my dilemma, and asked what he thought. He said it was clearly a good business decision to go with Cylink, and we did. It was the same decision I would have made on my own, but this way I can rest assured that I hadn't fooled myself again. Getting outside help when you're emotionally involved in an issue is a key element to living a more ethical life.

Lesson #3: Friends are better than enemies

Even though Stanford partnered with Cylink, we still didn't make much money from our patents while RSA was sold a few years later for $250 million. But, far from still being mad at my three MIT colleagues who had founded RSA, I am now friends with them them along with Jim Bidzos, who was CEO of the company and directed its legal battle. How did that happen?

After the patent fight ended, and as Dorothie and I progressed on our journey, I realized that being mad at them was inconsistent with my effort to lead a more ethical (and happier) life. So I tried re-thinking the legal battle through from their point of view, much as I had learned to see our marital conflicts through Dorothie's eyes as well as my own. With that new perspective, I approached Jim Bidzos. He, in turn, helped reconnect me with my three MIT colleagues. In a short time, we were able to turn animosity into friendship.

A similar thing had happened earlier with NSA, with the credit for resolving that conflict going to Admiral Bobby Inman, the Director of the Agency at the time. In 1978, I got a call from the Director's Office at NSA and was told that Admiral Inman would be in California and, if I were willing, he would like to meet with me. Up to this point NSA and I had been fighting it out in the media and indirectly, with either NBS or IBM (which had done the basic design of DES) acting as NSA's mouthpiece. I jumped at the chance to talk directly with the Agency, especially at this level.

When we met in my Stanford office, one of the first things Admiral Inman told me was, "It's nice to see you don't have horns." I returned the compliment, since I had seen myself as Luke Skywalker to NSA's Darth Vader. I was in my early thirties at the time, so the young hero model was more appropriate than it would be now, when I am in my seventies.

He also told me that he was meeting with me against the advice of all the other senior people at NSA. Inman said he understood their concerns but he didn't see any harm in talking. Over the intervening years, I have learned that such out-of-the-box thinking is typical of Inman.

Our relationship was cautious at first, but it grew into friendship as we came to appreciate one another's concerns. About ten years ago, both Admiral Inman and Jim Bidzos signed a statement of support for my effort to bring a more objective, risk-informed approach to America's nuclear strategy. They wouldn't have done that if they hadn't agreed with the statement, but they also wouldn't have done it if they hadn't trusted me.

Admiral Inman also signed a statement of support for my current project, "Rethinking National Security," which I'll say a bit more about later. More details are available on its website and in a report issued by the Federation of American Scientists.

Most people would agree that friends are better than enemies, but how many are willing to do the hard work necessary to effect that miraculous transformation? As these examples show, it is possible and it's one more lesson in accelerating our ethical evolution: Friends really are better than enemies.

Lesson #4: Get Practice by Correcting Even Minor Ethical Lapses

In 1976, I thought I had brushed the devil off my shoulder, but I had fooled myself and behaved unethically without realizing it. Roughly ten years later, when Lew Morris approached me with his business proposition that might hurt RSA, I recognized that I might be fooling myself. What had happened to allow me to recognize potentially unethical behavior that earlier I would have missed seeing?

After seeing The Day After Trinity in 1981, I vowed I would never fool myself again. From then on, I practiced ethical decision making on a daily basis by regarding even minor lapses, such as mistreating the woman I had vowed to love, as unethical. During our wedding ceremony, I had vowed to love Dorothie in good times and in bad. Mistreating her "in bad times" surely was not loving, so it also was unethical. By "lowered the bar" to what I regarded as unethical behavior I got constant practice at being a better person.

If you want to bench press hundreds of pounds, you can't just try to do it every time a weight lifting contest comes along. You have to constantly work out and build up your muscles. In the same way, if I only practiced ethical decision making when big decisions came along, such as challenging DES' key size in 1976 or accepting Cylink's offer in 1986, I likely would fail.

By correcting even "minor" ethical lapses, I got constant practice at living more ethically. All that practice paid off by creating a more loving, enjoyable home. But it also paid off when Lew Morris approached me with an offer that might make me money and had the side "benefit" of hurting people I then was mad at. I was able to see the danger of possibly fooling myself and seek Dorothie's help to ensure that I was making my decision in an ethical manner.

How lucky we are that life is constantly presenting us with opportunities to build up our ethical muscles. We just have to recognize those moments as opportunities, rather than getting mad or doing something else that is both unethical and ineffective.

Lesson #5: Ethical standards evolve, so becoming ethical is a process, not an end point.

George Washington and Thomas Jefferson were ethical by the standards of their day, but in today's world, as slaveowners, they would be guilty of a crime against humanity.

The British legal system that hounded Alan Turing[2] to death over his sexual orientation was enforcing the ethical standards of the 1950s. Today, we have evolved to the point that we look back in horror at society giving him a choice between prison and chemical castration due to his homosexuality. He chose chemical castration and committed suicide soon thereafter.

It's easy to see unethical behavior in the past. It's much harder to see current societal behavior that will be seen as unethical in the future.

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[2] As depicted in the recent movie, *The Imitation Game*, Turing was a hero for his codebreaking work during World War II. His fundamental contributions to computer science were recognized by naming that discipline's highest award in his honor. I received the ACM Turing Award in 2015, a prerequisite to my addressing you in Lindau today.

We can accelerate our ethical evolution by applying the same rigorous analysis that we use to advance science to the issue of ethics. Hard questions are welcomed, not brushed aside. Fundamental assumptions that masquerade as axiomatic truths are questioned.

One of my most influential mentors, the late Prof. Harry Rathbun, defined the scientific spirit as "a zealous search for the truth, with a ruthless disregard for commonly held beliefs when they are contradicted by the observed data." But going beyond his scientific training—Harry's undergraduate degree was in electrical engineering—he advocated applying the scientific spirit to ethical issues such as nuclear weapons and war. Here are three questions that I propose as a starting point for Harry's zealous search for the truth.

> First, how ethical is society's current approach to nuclear weapons? Have we done all that we reasonably can to minimize the risk of committing genocide that would dwarf the Holocaust and the carnage of the Second World War? Has society carefully weighed the risks of its current nuclear strategy versus alternatives? Has society diligently searched for alternative strategies other than the obvious (and unworkable) one of immediate and complete disarmament?
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> Second, which recent wars have been ethical? Which have backfired and created the opposite of their intended effects? Have we learned from those that backfired so that we will not repeat those mistakes and cause additional, needless human suffering?
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> Third, how ethical is society's current response to climate change? Are our actions consistent with the costs, the risks, and the uncertainties?

Because ethical norms evolve, becoming an ethical person is a process or practice. It is an ideal that, at best, can be approached as an asymptote. It is not an end point that one ever reaches. Being open to seeing and correcting one's current failings is essential to that process.

Lesson #6: Technology has made it essential to accelerate the evolution of our ethical behavior.

Science and engineering have given us physical powers that traditionally were thought of as belonging only to the gods. For example, in the Judaeo-Christian tradition, only God could destroy cities with thunderbolts. Today, we can do the same with nuclear weapons. Only God could cause a flood that would necessitate Noah building an ark, whereas human-induced global warming threatens similar devastation. Only God could create new life forms, whereas genetic engineering allows us to do so routinely.

In contrast to the godlike physical power that technology has given us, humanity's ethical progress is, at best, at the irresponsible adolescent phase. Nuclear weapons, environmental crises, and genetic engineering are symptoms of a deeper, underlying problem: the chasm between our technological power on the one hand and our ethical development on the other. Humanity is like a sixteen-year-old with a new driver's license who somehow got his hands on a 500-horsepower Ferrari. We will either accelerate our ethical evolution or we will kill ourselves.

Society behaves as if the various threats we face are tolerable, so it pays to look at nuclear war, which I am convinced is the greatest immediate risk at this moment. It is the only man-made threat that could destroy civilization as I speak to you.

Over the last ten years, I have asked hundreds of people how many years they think nuclear deterrence can be expected to work before it fails and destroys civilization as we know it?

Since that is a hard number to quantify, I ask them to do this only to an order of magnitude—the nearest power of 10.

While there are exceptions, almost everyone sees ten years as too short for this "nuclear time horizon" and a thousand years as too long. That leaves one hundred years as their order of magnitude estimate, which corresponds to a risk of roughly 1% per year. Over the next decade that corresponds to almost 10%, and it results in less than even odds over the life expectancy of a child born today in the developed world.

Such an order of magnitude estimate works best with a technical audience such as this one and fortunately there's another way to describe the risk that communicates to a general audience. Imagine that a man wearing a TNT vest were to come into this room and, before you could escape, managed to tell you that he wasn't a suicide bomber. He didn't have the button to set off the explosives. Rather, there were two buttons in very safe hands. One was in Washington with President Trump, so just sit back and enjoy my lecture. The other button was in Moscow with President Putin, so again there was nothing to worry about. You'd still get out of this room as fast as you can![3]

Just because we can't see the nuclear weapons controlled by those two buttons, why do we stay here? As if confronted by that man in the TNT vest, we need to be plotting a rapid escape. Instead, we have sat here complacently for over 50 years, trusting that because the Earth's explosive vest hasn't yet gone off, it never will.

Lesson #7: There is hope of humanity becoming more ethical

If you agree with lesson #6, that accelerating our ethical evolution is essential for humanity's progress to continue, the next question becomes, "Is there any hope of doing that?"

I know there is hope of success because I have experienced it personally, transforming a marriage that was on the brink of divorce to one where my wife and I thank each other daily for the little bit of heaven we have brought down to earth. Since that should not be a major theme at a conference on physics, I'll refer those interested to the free PDF of our book for details.

A second reason for hope may seem paradoxical at first: over the 35-plus years that I have worked on these issues, many people have told me I was on a fool's errand. I see that as hopeful because many of the best ideas appear foolish before they pay off. That was certainly true for me.

My colleagues told me that I was foolish to work in cryptography until I started getting the results that led to my addressing you today as a winner of the ACM Turing Award. Many other winners of top awards have told me similar stories. Due to the limits of time, I will not give those other examples, but I will refer you to a video of my talk on The Wisdom of Foolishness. I also suggest that you ask the Nobel Laureates in attendance if they experienced similar

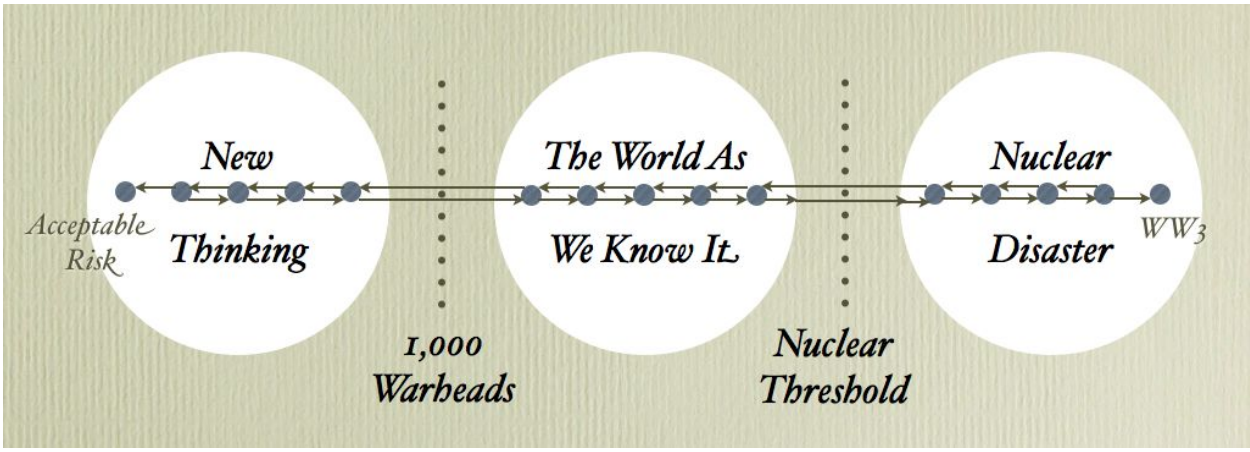
[3] The risk is even greater because that story should have additional buttons in London, Paris, Beijing, Jerusalem, New Delhi, Islamabad, and Pyongyang—and terrorists are trying to get one of their own.

discouragement early in their work. I am confident that many, and probably a majority, will say that they did. The best results often look foolish *a priori*.

A third element of hope is that we need to accelerate humanity's ethical evolution, not start the process from scratch. Over just the last century or two, many parts of the world have done what earlier seemed impossible. They abolished slavery, established universal suffrage, improved human rights, and started to tackle environmental degradation including climate change.

We have even made significant progress on reducing the nuclear threat. The world's arsenal has fallen from a peak of approximately 70,000 warheads in 1986 to 14,000 today. Such a reduction was inconceivable thirty-five years ago when the Freeze movement took on the seemingly impossible task of ending the arms race. That movement would have been seen as even more quixotic if it had tried to reduce the world's nuclear arsenals by 80%. But that is precisely what has happened to date.

Those past examples of ethical progress provide real hope that we can continue and even accelerate the process, leading to a third element hope: the fact that societal change occurs as a process, not a discontinuous jump. This was depicted in the figure below, taken from my 2011 paper in *The Bulletin of the Atomic Scientists*, "How risky is nuclear optimism?



Today, we are in a state near the middle of the superstate labeled "The World As We Know It," and it is hard to envision how we could end up either in the extreme state denoting World War III or the state at the other end of the figure where the risk of a nuclear war is at an acceptable level.

It is impossible to transit directly from the state we are in today to either of those extreme states, so the critics who say that World War III cannot happen have a point: it cannot happen without a number of state transitions. But they are wrong in the long-run as we move to different states within our current superstate. That's what happened in 1962, leading to the Cuban Missile Crisis during which the world teetered on the nuclear abyss.

Critics who say that we cannot build a world where the nuclear threat is a nightmare of the past also have a point. We cannot reach that state from the one we are in today. But, if we move in the right direction, we create new possibilities.

If we accept the above figure's somewhat arbitrary definition that the transition from our current superstate to the one labeled "New Thinking" occurs when the world's nuclear arsenal falls to 1,000 warheads, we are still a bit more than an order of magnitude away (14,000 warheads) from making that superstate transition, but we have already moved almost an order of magnitude in the right direction from the peak of the arms race (70,000 warheads).[4] That is a really hopeful sign!

While the above diagram only addressed the risk of nuclear war, similar diagrams apply to the other existential threats facing humanity, and there is strong coupling between motion in one dimension (e.g., nuclear risk) and the others (e.g., climate change).

While we have made significant progress in all dimensions related to the survival of civilization, we still have far to go. And, as recent events make all too clear, there will be many backward steps during the process. But we should not let those setbacks blind us to the tremendous progress we have already made.

Lesson #8: Everyone Can Play a Role

Many of you are already working to solve one or more of the existential problems we face and I am honored to be speaking at the same series of Lindau Meetings that gave rise to both the Mainau Declaration of 1955 on nuclear weapons and the Mainau Declaration of 2015 on climate change. (The former was signed by 52 Nobel Laureates and the latter by 76.) In many ways, this talk can be viewed as seconding those two Mainau Declarations and I encourage you to read them.

But even when one is a Nobel Laureate, I am sure the question frequently arises: What can I, a single individual, do to help solve such huge problems? A friend of mine who is a US congressman and has even more power said roughly the same thing to me. He is only one of 435 members of our House of Representatives, even if he got the House to agree the Senate would need to do the same, the president would have to agree, and the voters would have to keep them all in office even though they questioned the conventional wisdom on national security. Those things are not going to happen while we are in our current substate within "The World As We Know It" superstate.

No one person can solve this problem, not even a Nobel Laureate or a US congressman. But if enough of us move things a little, together we can change the substate of the world and create new possibilities. That's how slavery ended, women got the vote, and more.

The most effective thing we can do to advance society's ethical evolution depends on the issue being addressed. The risks associated with human-induced climate change already have significant public awareness, but not universal agreement, so it is possible to take actions such as supporting political candidates who have taken strong positions on combatting climate change or lobbying your government to take action.

In contrast to climate change, the risks associated with nuclear weapons are unappreciated by the general public. For that reason, the most effective action is to talk with people and raise awareness. Once there is greater awareness, concrete changes will become possible again. (They were possible in the 1980s when public awareness was at its peak. In fact, the 80% decline in the size of the world's nuclear arsenal started during that period of intense public concern.)

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[4] On a logarithmic scale, we are approximately 40% of the way from the peak arsenal size of 70,000 warheads to the 1,000 required to cross the threshold to the "New Thinking" superstate. That's because log(70) = 1.85, log(70/14) = 0.70, and 0.70/1.85 = 38%, which rounded is 40%.

I talk about nuclear risk with ordinary people whom I meet, as well as with members of my government. The latter conversations tend to be "quiet" and I often point out that I am not proposing that a politician make this a campaign issue at this stage in the process. Even though these conversations are quiet, they raise questions that can affect how members of Congress vote and the questions they ask in hearings. That in turn can affect media coverage and the public's perception.

I also encourage the members of Congress with whom I have relationships to share their concerns with their colleagues, again quietly. Hearing something from multiple sources makes a deeper impression.

Whether you talk to members of your government (more likely for the Laureates) or to the general public and use social media (more likely for the young researchers), you still will have an impact. And you cannot know what that impact will be ahead of time as the following example illustrates.

Several months ago, a friend was at a dinner unrelated to these issues and the man sitting next to him asked what he did. My friend gave the 30-second summary for our project on "Rethinking National Security":

> In 1945 US national security was unquestioned. Trillions of dollars later we can be destroyed in under an hour. Isn't it time we started rethinking national security at a fundamental level?

My friend's table-mate was intrigued and offered to help. As the three of us talked, we learned that his table-mate was a close friend of an influential member of the United States Congress. We are now talking with that congressman and his staff about these issues. My friend did not know in advance that a simple dinner conversation would end up having that much impact. But he talks with many people which increases the odds of such a payoff.

It helped get the congressman's attention that a statement of support for "Rethinking National Security" has been signed by Adm. Inman, who was Director of NSA from 1977-1981, and several others with impeccable national security credentials. Four Nobel Laureates have also signed and I hope that some of you may want to do the same. (While that statement is intended for American signers, I have an international version that will be publicized when it has an adequate number of prominent signers to merit attention. Contact me if you want to see it.)

Those of you from other nations can play a major role, even if your nation has no nuclear weapons. In fact, that may be an advantage because non-nuclear nations are not as invested in the myth of the power of nuclear weapons.

The 2017 Nobel Peace Prize was awarded to ICAN (The International Campaign to Abolish Nuclear Weapons) partly "for its ground-breaking efforts to achieve a treaty-based prohibition of such weapons." The UN vote on that treaty passed the General Assembly without support from any nuclear weapons states or NATO members. Non-nuclear nations led the way.

If enough of us work at accelerating humanity's ethical evolution, together we will not only triumph over the threats we face; we will also build a more peaceful, sustainable world that we can be proud to pass on to future generations. However you choose to work on accelerating humanity's ethical evolution—be it on climate change, nuclear weapons, or in some other way—you have my thanks. I hope that the lessons I've learned and discussed today prove helpful in that effort.

I will close with a lesson that I learned from Prof. Harry Rathbun. Harry pointed out that there are two hypotheses: Either we are capable of the great changes needed to ensure humanity's survival—that's the nobler hypothesis—or we are not. If we assume the less noble hypothesis, we will be doomed even if we have the capacity to change. But, if we assume the nobler hypothesis, the worst that happens is we go down fighting. And the best that happens is that humanity continues its awesome evolutionary arc. "Why not assume the nobler hypothesis?" Harry concluded. It made sense to me then, and it still does today.

References

[Diffie and Hellman 1977] W. Diffie and M. E. Hellman, "Exhaustive cryptanalysis of the NBS data encryption standard," *Computer*, vol. 10, no. 6, pp.74-84, June 1977. Accessible online.

[Nathan and Norden 1981] Otto Nathan and Heinz Norden, editors, *Einstein on Peace*, New York, Avnel Books, 1981, page 376.

[NBS 1977] National Bureau of Standards, *Data Encryption Standard*, Federal Information Processing Standard (FIPS) Publication no. 46, Jan. 1977. A later version, FIPS PUB 46-3, is accessible online.