Facing Existential Risk:

How the US Survived the Atom Bomb and the Ozone Hole

William Heegaard

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Written under the direction of Professors Alan Karras, Stephen Gross, and Kate O'Neill

Abstract

This project seeks to examine the history behind US understanding of human extinction, and how existential risk has shaped American foreign policy. It traces the evolution of US anxiety over nuclear war and ozone depletion. America's perception of nuclear war was shaped by military secrecy, public fear, and scientific discussion. While national security demanded staying one missile ahead of the Soviet Union, scientists worried about the effects of radioactive fallout after a total nuclear war. The risk of global annihilation through decision-making peaked in the Cuban missile crisis. President Kennedy's perception of nuclear war as an existential risk drove him to avoid military conflict with the Soviet Union at all costs.

The facts and fears carried over from the atomic age grounded America's open investigation into the ozone layer. A systematic process of research and debate led the public to believe human impact on the stratosphere was a direct threat to global survival. The ozone layer's fragility proved interstate cooperation was a national security requirement, and evidence tying chlorofluorocarbon (CFC) emissions to ozone depletion generated a strong domestic movement to eliminate aerosols. The US perception of ozone depletion as an existential risk drove the construction of the first global regulatory regime for earth's environment. When nations believe something will end them all, they cooperate to prevent it from happening.

Contents

Introduction

"The perception of risks that are increasingly capable of circumventing and transcending territorial boundaries poses the question of how states will respond. This leads to further questions such as what effects risk will have for domestic politics and governance within states, and how this will be reflected in their interstate conduct."[1]

- An American story

On March 6, 2012, *The Atlantic* published an online article provocatively titled "We're Underestimating the Risk of Human Extinction."[2] Covering an interview with Oxford's Professor Nick Bostrom, Ross Andersen described the recent academic investigation into the possibility of human beings loosing their ability to survive and flourish on planet earth. As a species, we have been lucky enough to avoid natural existential threats – supervolcanic eruptions, large asteroid impacts, gamma-ray bursts, nearby supernova explosions, etc. – without any awareness, recognition, or conscious mitigatory action on our part. Only in the last century have humans realized that their extinction is a legitimate possibility, and that specific actions are needed if they care to prevent it. As Bostrom explains, new technologies have given us the means "to create new kinds of weapons or new kinds of accidents," generating "new kinds of risks that haven't existed to this point in human history – in particular risks of our own making."[3]

The idea that humans could go extinct has long been confined to the realm of spiritual prophecy. The Book of Revelations foretold the end of days, in which all people on earth face final judgment, and the world as we know it ends in a series of unfortunate horrors. While the apocalypse has an extensive history as a supernatural fear, it has only recently become a scientifically plausible. Today's conservation biologists have measured how 99.9 percent of all

[1] William Clapton. "Risk in International Relations." *International Relations* 25 3 (2011): 280–295.
[2] Ross Andersen. "Were Underestimating the Risk of Human Extinction." *The Atlantic*. March 6, 2012. <http://www.theatlantic.com/technology/archive/12/03/were-underestimating-the-risk-of-human-extinction/253821/#>
[3] Ibid.

species that existed on earth are extinct, providing the factual basis for asking the question: could human beings be next, and if so, how?[4] More specifically, when has the human race come close to its own elimination, and how have people – scientists, politicians, civilians, etc. – responded? What decisions have been made to prevent us from joining the dinosaurs, and how do such actions explain the behavior of nations at a global scale?

Human extinction, both as an objective fact and a subjective fear, is a unique product of American history. As I hope to show, the United States (US) was the first country to develop the power to physically eliminate humans from planet earth, and the strategies adopted to manage that risk shaped the evolution of US foreign policy. The story of nuclear war and ozone depletion is the story of how US scientists, civilians, and leaders realized they could create the conditions for their own extinction, and how that changed the fundamental tenants of international relations.

Survival is a powerful motivator, and American history offers a distinct case study for examining how the people of a nation perceive and react to danger. Unlike Israel, Georgia or other countries that evolved in the face of imminent attack, the US developed in a context of relative geopolitical security. By the early 20th century, it faced few foreign threats to state sovereignty or long-term survival. Rapid industrial and military growth transformed America into an unchallenged regional power, and when Pearl Harbor launched the US into World War II, the Atlantic and Pacific oceans provided a wide buffer that protected from any assault on the civilian population. From across the world, the US watched as France collapsed under the German offensive and Britain fought to prevent total destruction of its homeland. The Soviet Union lost around twenty-seven million people – over ten percent of its population – and the

[4] Reinhard Stindl. "Is Telomere Erosion a Mechanism of Species Extinction?" *Journal of Experimental Zoology* (2004): 111-120.

majority of them were noncombatants.[5] While Americans buried hundreds of thousands of their soldiers, they never confronted the existential crisis of invasion, national collapse or mass citizen death. There was no blitzkrieg across the Canadian border or fire bombings of New York City. The first real threat to US survival was its own invention: the atom bomb.

For the new leader of the free world, nuclear supremacy was a top national security priority, and the US led the world in atomic innovation. While Manhattan project scientists warned of militarizing into extinction, the US government secretly built a strike force capable of incinerating the Communist block in twenty-four hours. Balancing the environmental risk of atomic conflict with the ideological threat posed by the USSR, Americans looked for evidence to quell their apocalyptic fears. The exact data was kept classified beyond top secret, but the implications were clear. The potential blast, fire, and radiological damage from a total nuclear war meant that an "atomic war fought with greatly perfected weapons and pushed by the utmost determination will endanger the survival of man."[6]

The obvious global consequences of total war gained widespread attention through the late 1950s, and shaped President Kennedy's perception of nuclear risk. Aware of the largely unknown planetary effects of nuclear war, Kennedy rejected the urge to take advantage of America's massive nuclear superiority over the USSR while he had the chance. He recognized that any direct conflict would jeopardize global environmental systems – air, water, soil – the US depended on for survival.

The possibility of human extinction through war pushed Kennedy to reject military force in the face of a belligerent threat to US national security. When the CIA discovered nuclear

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[5] Michael Ellman and S. Maksudov. "Soviet Deaths in the Great Patriotic War: A Note." *Europe-Asia Studies* 46, (4) (1994): 671-680. See also: "Leaders mourn Soviet wartime dead." *BBC News*. May 9, 2005. <http://news.bbc.co.uk/2/hi/europe/4530565.stm>

[6] Edward Teller. "How Dangerous Are Atomic Weapons?" *Bulletin of the Atomic Scientists*, Vol. 3 (2) (February 1947).

missiles in Cuba, the President stood up to the immense challenge of removing the missile threat without increasing the unacceptable risk of atomic conflict with the Soviet Union. Despite substantial domestic pressure to invade Cuba and confront the USSR, Kennedy resolved to stall the US war machine and pursue diplomacy until bombs fell on the White House. The President's perception of the stakes of the crisis, along with his clear responsibility for its outcome, drove him to avoid the "final failure" at all costs.[7]

In a context of extremely high military tension, Kennedy and Khrushchev found common ground in mitigating the possibility of atomic apocalypse. Their mutual belief that nuclear war was not survivable led to one of the most profound empathic breakthroughs in human history. The crisis left both governments painfully aware of the imminent, collective hazard posed by nuclear weapons, and the two ideological enemies took their first steps in a long process of nuclear disarmament. The Limited Test Ban Treaty (LTBT) of 1963 ended the practice of testing nuclear weapons above ground, under water or in space, and the two superpowers slowly stepped back from the brink.

America's brush with nuclear extinction ushered in a new era of open investigation into how humans impacted the environment. In the mid 1960s, civil atmospheric science paved the way to a clear factual understanding of the stratosphere, and early ozone research confirmed the ozone layer's vital role in protecting living organisms from lethal UV radiation. Amidst growing public concern for global environmental degradation, the federal government sponsored investigations into the effects of supersonic transport (SST). Preliminary evidence showing potential human impact on the stratosphere sparked American curiosity. In a wave of open discoveries, US scientists proved that compounds released from SSTs, space shuttles, nuclear

[7] Timothy Naftali and Philip Zelikow. *The Presidential Recordings: John F. Kennedy Vol. 2, The Great Crisis.* (W. W. Norton: New York, 2001). Pg. 541.

weapons and certain household products would incrementally destroy the ozone layer, increasing human exposure to shortwave UV radiation and ultimately leading to the sterilization of the earth's surface. Despite substantial industry effort to obscure the scientific consensus, the public quickly recognized ozone depletion as an existential risk.[8] Their direct responsibility in contributing to a future of ecological chaos set off an immediate change in consumer behavior, and inspired them to eliminate CFCs in aerosol spray cans.

The forceful domestic response to the CFC threat drove the US government to lead the construction of an international regime capable of protecting the stratosphere from inadvertent destruction. For Americans, the ozone layer was proof of the fragility of the earth's ecological support system, and highlighted the urgent need for international dialogue and cooperation to mitigate catastrophe. Its discovery called into question long-held truths from traditional security disciplines, breaking down the logic of the arms race with photochemistry and atmospheric physics.

International ozone negotiations initially stalled, but evidence of a growing ozone hole over Antarctica removed any doubt that CFCs were a global existential risk. With strong backing from the US, Canada, and select European allies, the world's nations designed and implemented the Montreal Protocol. American concern for the long-term environmental effects of ozone depletion led to the "single most successful international agreement to date."[9] A strong US belief in the irreversible consequences of unilateralism drove international cooperation in the face of political and economic opposition.

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[8] An existential risk is "one where an adverse outcome would either annihilate Earth originating intelligent life or permanently and drastically curtail its potential." Nick Bostrom. "Existential Risks: Analyzing Human Extinction Scenarios and Related Hazards." *Journal of Evolution and Technology*, Vol. 9, March 2002. <http://www.nickbostrom.com/existential/risks.html>

[9] Kofi Annan. Quoted in "International Day for the Preservation of the Ozone Layer: 16 September." *The United Nations*. <http://www.un.org/en/events/ozoneday/background.shtml>

- Threat and risk

US policy towards nuclear war and ozone depletion was grounded in perception. How America managed these hazards depended on who dictated the outcome and how their beliefs translated to decision. Fear was subjective; American's based their actions on impulses, experiences and opinions. Together, their choices – from the President's to the housewife's – defined how the US collectively reacted to the atomic bomb and the ozone hole. This project seeks to explain how the belief that either would cause human extinction shaped US foreign policy, from fighting Soviet communism to cooperatively managing the global commons.

The distinction between threat and risk helps explain how we have prioritized different hazards. These two concepts are not meant to be definitive, but offer a loose framework for evaluating how individuals and societies categorize their fears.

A threat is an immediate, measurable danger to something of value. It refers to events causing potential damage in the future, not harm experienced in the present. In international politics, states use threats as political tools to compel other states to do what they otherwise would not want to do.[10] The realized threat of war is simply war.

Labeling something a threat essentially suggests that it is actively moving to overcome the subject's defenses and cause direct injury. National security analysts classify the level of a threat by examining the "capability of the enemy and their intent or motivation, in addition to one's own vulnerability."[11] In this case, the source of the threat is a territorial sovereign nation

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[10] See Peter J. Anderson. *The Global Politics of Power, Justice and Death: An Introduction to International Relations.* (Routledge: New York, 1996). Pg. 12.

[11] Myriam Dunn Cavelty. "From Threats to Risks in International Security – and Subsequent Challenges for 'Knowing' the Future." *International Relations and Security Network*. November 16, 2011. <http://www.isn.ethz.ch/isn/Current-Affairs/Special-Feature/Detail?lng=en&id=134110&contextid774=134110&contextid775=134111&tabid=134111>

and its capability of dealing damage. However, it is easy to imagine other obvious and immediate sources of damage: Al-Qaeda, the AIDS virus, Hurricane Katrina, or malware. Threats imply a relatively high degree of certainty about the cause and scope of future harm.

As I hope to show, the changing nature of conflict throughout the second half of the 20th century forced Americans rethink what actually endangered their security. The idea of a threat, understood as a military problem deliberately created by one group of people for another, grew progressively less useful for describing and managing hazards to American wellbeing. Several of the new challenges that security policy started to face – environmental damage, global health issues, financial stability, critical infrastructure protection – "seemed much better captured by the concept of risk."[12]

Risk is predicated upon uncertainty. In some cases, the possible outcomes and their respective probabilities are known – the uncertainty is described, or structured. In others, the probability distribution of outcomes is ambiguous. Either the percentage chance that each outcome will occur is uncertain, or there is a lack of information even regarding which outcomes should be included as possibilities.[13] This most extreme form of uncertainty is what Donald Rumsfeld has called "unknown unknowns."[14] Like threats, risks denote the possibility of losing something of value, but they do not necessarily imply any point source or active cause of harm. Risks are multivariable, indirect, and unintended.[15] The continuum between definite threats and unknown risks will be my launching point for studying how Americans have understood human

[12] Myriam Dunn Cavelty.
[13] Yaacov Y. I. Vertzberger. *Risk Taking and Decision Making: Foreign Military Intervention Decisions.* (Stanford University Press: Stanford, 1998).
[14] Yaacov Y. I. Vertzberger. "Rethinking and Reconceptualizing Risk in Foreign Policy Decision-Making: A Sociocognitive Approach"; Donald Rumsfeld. DoD News Briefing - Secretary Rumsfeld and Gen. Myers. News Transcript. February 12, 2002
[15] Myriam Dunn Cavelty.

extinction. Since it cannot be objectively measured, extinction is by definition a risk.[16]

Current scholarship on the influence of risk perception in international relations has so far limited itself to an ontological debate over whether risk is material or imagined.[17] While economists claim risk is an objective function of probability and harm, sociologists argue for the need to take into account the social construction of risk.

This project seeks to sidestep that debate by studying how the perception of nuclear and ozone risk translated into action. Acknowledging the fact that some risks may be measurably more probable and damaging than others does not require us to turn a blind eye to the value systems that shape these measurements. Rather, it is possible to understand risk perception as a constant interplay between the physical threats of our material environment and the cognitive processes that humans use to manage these threats. As Yaacov Vertzberger explains:

> "Perceived risk… is the level of risk attributed to a situation or behavior by the decision-makers. It assumes the impossibility of a standard of absolute risk, and that perceived risk need not be, and often is not, congruent with the actual risk. This incongruence may be cause by unavailable information, misperception, and misinterpretation. Thus, the response of different individuals and groups facing the same type and level of actual risk may vary because of dissimilar risk perceptions."[18]

People make decisions based on what they think is real. By tracing the history of nuclear war and ozone depletion, I hope to show how Americans collectively realized our agency in ending or saving the human race, and how that changed our attitudes towards war, the environment, and global politics.

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[16] It is conceivably possible to objectively study the risk of human extinction, but it would require identifying earthlike planets in nearby galaxies and running large-scale tests over a series of generations in order to determine the full effects of a total nuclear war, complete elimination of the ozone layer, etc.
[17] William Clapton.
[18] Yaacov Y. I. Vertzberger. "Rethinking and Reconceptualizing Risk in Foreign Policy Decision-Making: A Sociocognitive Approach."

The Atomic Age

> "No notion of risk is to be found in traditional culture: pre-industrial hazards or dangers, no matter how potentially catastrophic, were experienced as pre-given. They came from some 'other' – gods, nature or demons. With the beginning of societal attempts to control, and particularly with the idea of steering towards a future of predictable security, the consequences of risk become a political issue. This last point is crucial. It is societal intervention – in the form of decision-making – that transforms incalculable hazards into calculable risks."[19]

- Trinity

On July 16th, 1945, the men of the Manhattan project gathered in the Jornada del Muerto desert of New Mexico to watch the first physical test of an atomic bomb. Some scientists placed bets on what would happen; they ranged from nothing to the incineration of earth's atmosphere. Physicist I. I. Rabi was closest with a prediction of eighteen kilotons of TNT.[20] After six years of top-secret research, the "remarkable partnership of science, industry and government" waited for the clock to strike 5:30 am.[21] The explosion lit up the sky, and Robert Oppenheimer later reflected,

> We knew the world would not be the same. Few people laughed, few people cried, most people were silent. I remembered the line from the Hindu scripture, the *Bhagavad-Gita*. Vishnu is trying to persuade the Prince that he should do his duty and to impress him takes on his multi-armed form and says, "Now I am become Death, the destroyer of worlds." I suppose we all thought that, one way or another.[22]

Six months before the test, Oppenheimer ordered a thorough study into the theory that a thermonuclear chain reaction could expand "to all parts of the atmosphere."[23] If the energy released from splitting the atom generated enough heat – a temperature that was theoretically possible, but astronomically high – the nitrogen atoms in the atmosphere would fuse, sparking a

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[19] Anthony Elliot. "Beck's Sociology of Risk: A Critical Assessment." *Sociology* 36 (May 1, 2002): 293.
[20] Richard Rhodes. *The Making of the Atomic Bomb*. (Simon & Schuster: New York, 1986). Pg. 656-677.
[21] McGeorge Bundy. *Danger and Survival: Choices About the Bomb in the First Fifty Years*. (Random House: New York, 1988). Pg. 52.
[22] Robert Oppenheimer. Interview. *Hiroshima: The Decision to Drop the Bomb*. TV documentary produced by Fred Freed, NBC. 1965.
[23] Edward Teller, Emil Konopinski and C. Marvin. "LA-602: Ignition of the Atmosphere with Nuclear Bombs." 1945 (Declassified July 30, 1979). <http://www.fas.org/sgp/othergov/doe/lanl/docs1/00329010.pdf>

chain reaction that would incinerate the earth's surface. Titled "Ignition of the Atmosphere with Nuclear Bombs," the report represented the first attempt to scientifically evaluate the uncertain risk of human extinction.[24]

Under Edward Teller's leadership, Emil Konopinski set about assessing the probability that an atomic explosion would end the world. Teller had already calculated that the heat produced by an atomic explosion could cause hydrogen atoms to fuse. Nitrogen had its own tipping point, but no one had measured what it was. Using extremely conservative benchmarks, Konopinski concluded that such temperatures were well beyond the bounds of present human capability, and even if they were possible, "the energy loss to radiation" would prevent the reaction from expanding indefinitely.[25] His research confirmed "no self-propagating chain of nuclear reactions is likely to be started" with the bombs "now under consideration."[26]

While there was little chance a nuclear explosion would release enough heat to fuse atmospheric nitrogen, there was no way to confirm it without actually splitting the atom. The Manhattan project had set out to do something unprecedented in human history, leaving Teller and Konopinski with a profound "absence of satisfactory experimental foundations" to ground their calculations. "It is not inconceivable that our estimates are greatly in error and thermonuclear reaction may actually start to propagate."[27] There also remained the "distant probability that some other less simple mode of burning may maintain itself in the atmosphere."[28] And "even if the reaction is stopped within a sphere of a few hundred meters radius, the resultant earth-shock and the radioactive contamination of the atmosphere might

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[24] Anders Sandberg, Jason Matheny and Milan Cirkovic. "How can we reduce the risk of human extinction?" *Bulletin of the Atomic Scientists*. September 9, 2008. <http://www.thebulletin.org/web-edition/features/how-can-we-reduce-the-risk-of-human-extinction>
[25] Edward Teller, Emil Konopinski and C. Marvin.
[26] Ibid.
[27] Ibid.
[28] Ibid.

become catastrophic on a world-wide scale."[29] It was impossible to be certain that splitting the atom wouldn't ignite the atmosphere until they actually detonated one. The irreducible uncertainty of existential risk left scientists betting on the world's future. On July 16th, 1945, they stood in the Jornada del Muerto desert and waited for the Trinity test to prove the pessimists wrong.

The atmosphere didn't explode, but the Trinity test set in motion a process of collective realization in the power of human ingenuity.[30] The US had developed the technological capability to affect natural systems on a planetary scale. The gaps in scientific understanding of those systems were huge, meaning that Americans could disturb them in ways they could not hope to know, much less reverse. Wielding a new weapon of unprecedented power, academics, policymakers, and citizens came to recognize how they could inadvertently create the conditions for their own extinction. As they confronted the legitimate "possibility of the destruction through decision-making of all [human] life on this planet," they became aware of their responsibility in preventing ignorance from sowing catastrophe.[31]

Living in an age of total war, the civilian scientists tasked with splitting the atom were painfully aware of the global implications of their endeavor. The physics behind a nuclear reaction was relatively simple. While the materials were harder to come by, it was only a matter of time before other nations achieved nuclear parity, foretelling a future of flames if the world's decision-makers couldn't mitigate the risk of nuclear war breaking out. Many Manhattan project participants believed the only way to communicate the scale of nuclear risk would be to show it, ending World War II with the atom to prevent an atomic Word War III. Along with many of his

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[29] Ibid.
[30] Leslie Groves. "Memorandum to the Secretary of War. Subject: The Test." July 18, 1945. <http://www.atomicarchive.com/Docs/Trinity/Groves.shtml>
[31] Ulrich Beck. *World Risk Society*. (Malden, MA: Blackwell Publishers, 1999). Pg. 53.

colleagues, Teller declined to sign a petition asking President Truman to give Japan a chance to surrender before "opening the door to an era of devastation on an unimaginable scale."[32]

> I do not feel that there is any chance to outlaw any one weapon. If we have a slim chance of survival, it lies in the possibility to get rid of wars… Our only hope is getting the facts before the people. This might help to convince everybody that the next war would be fatal. For this purpose actual combat use might even be the best thing.[33]

Teller articulated the challenge scientists faced in shifting the burden of nuclear knowledge and responsibility to the American people. Recognizing "the necessity of lifting the secrecy" that veiled public perception of nuclear risk, Teller believed that the facts would be made available "as soon as the military situation permits."[34] However, nuclear weapons were built behind the closed doors of a government at war, and there they would stay. While the existential implications of nuclear risk trickled down to the public, the facts that substantiated them – the numbers, target plans, explosive yields, etc. – remained locked in the highest echelons of America's national security apparatus.

The ideological struggle between the US and the Soviet Union shaped how nuclear weapons were made, understood, and managed. Nuclear superiority was key to asserting US leadership in the construction of a free and democratic world order. As the Soviet Union began to challenge US nuclear hegemony, a strong and effective nuclear arsenal became the War Department's primary instrument of national security, safeguarding America's borders from foreign attack by guaranteeing atomic retaliation. Although the USSR's nuclear weapons project lagged far behind in size and science, the threat of slipping from nuclear supremacy immediately raised concern, driving America's nuclear-industrial complex to build the conditions for planetary annihilation.

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[32] Leo Szilard. "A Petition to the President of the United States." First draft. July 3, 1945.
[33] Edward Teller. Letter to Leo Szilard. July 4, 1945.
<http://www.atomicarchive.com/Docs/ManhattanProject/SzilardTeller2.shtml>
[34] Ibid.

With the successful Trinity detonation, President Truman was immediately confronted with the question of whether to use the bomb on Japan or watch World War II drag to a slow and bloody halt in a land invasion. As McGeorge Bundy reflected, "the proper first object of policy was to win the war just as fast as possible, and… the use of the atomic bomb against cities was a legitimate instrument to this end."[35] While the President's decision was justifiable – dropping nuclear weapons minimized US casualties and brought a quick end to the war – critics charged that he was engaging in "atomic diplomacy."[36] Truman promised Americans that he would "get tough" with the Soviet Union, and took a decidedly more aggressive stance than President Roosevelt in checking the spread of communism.[37] Using the bomb on Japan would "convince the communist world that America had used nuclear weapons once and would not be afraid to use them again to assure U.S. domination of the postwar world."[38]

- Hiroshima

On August 6, 1945, the B-29 *Enola Gay* dropped the warhead "Little Boy" on Hiroshima. Investigations done a year later would estimate that 70,000 people were killed and 70,000 injured.[39] Over ninety percent of doctors and nurses were incapacitated, and only three of forty-five hospitals were left operational.[40] Three days later, "Fat Man" fell on Nagasaki.

The bombings shot nuclear weapons into public consciousness. "First Atomic Bomb Dropped on Japan; Missile Is Equal to 20,000 Tons of TNT; Truman Warns Foe of a 'Rain of

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[35] McGeorge Bundy. Pg. 82.
[36] Sheldon M. Stern. *Averting "the Final Failure": John F. Kennedy and the Secret Cuban Missile Crisis Meetings.* (Stanford University Press: Stanford, 2003). Pg. 2.
[37] Charles E. Bohlen. *Witness to History, 1929-1969*. (W. W. Norton: New York, 1973). Pg. 213.
[38] Sheldon M. Stern. Pg. 2.
[39] "U.S. Strategic Bombing Survey: The Effects of the Atomic Bombings of Hiroshima and Nagasaki." *President's Secretary's File, Truman Papers.* June 19, 1946. Found in the Harry S. Truman Library. <http://www.trumanlibrary.org/whistlestop/study_collections/bomb/large/documents/index.php?pagenumber=2&documentdate=1946-06-19&documentid=65&studycollectionid=abomb>
[40] Ibid.

Ruin'" boldly covered the August 6 edition of *The New York Times (NYT)*.[41] Down the side column: "'Impenetrable' Cloud of Dust Hides City After Single Bomb Strikes." While Moscow had known about the Manhattan Project since 1942, average Americans were "astounded to learn of the existence of a far- flung, government-run, top secret operation with a physical plant, payroll, and labor force comparable in size to the American automobile industry."[42] The project had designed a bomb 2,000 times more powerful than the largest conventional explosive ever made. "What is this terrible new weapon," wrote the *NYT* reporter on August 6,

> "which the War Department also calls the 'Cosmic Bomb'? It is the harnessing of the energy of the atom, which is the basic power of the universe. As President Truman said, 'The force from which the sun draws its power has been loosed against those who brought war to the Far East.'"[43]

The invention of atomic energy represented the beginning of a new age marked by unfathomable power. While the atoms' awesome capacity for destruction triggered an initial sense of dread, America's newfound ability to harness it promised a future of global peace and prosperity. As long as the US retained control, the atomic age would be bright.

The official US government statement on the development of the atomic bomb, called the Smyth Report, came out on August 12, bringing the Manhattan Project and its bomb into fuller view. [44] The report had been meticulously edited to prevent publishing any nuclear secrets, but citizens, wielding an extremely limited understanding of nuclear physics, worried that the Soviets would use it as an instruction manual for kick-starting their own atomic program. The profound gap in nuclear knowledge left ample room for misinterpretation. As Americans

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[41] Sidney Shalett. "First Atomic Bomb Dropped on Japan; Missile Is Equal to 20,000 Tons of TNT; Truman Warns Foe of a 'Rain of Ruin.'" *The New York Times*. August 6, 1945. <http://www.nytimes.com/learning/general/onthisday/big/0806.html>

[42] F.G. Gosling. "The Manhattan Project: Making the Atomic Bomb." *United States Department of Energy*. January 1999.

[43] Sidney Shalett.

[44] Henry DeWolf Smyth. *Atomic Energy for Military Purposes: The Official Report on the Development of the Atomic Bomb under the Auspices of the United States Government ,1940-1945.* (Princeton: Princeton University Press, 1945).

grappled with the bomb's global implications, their perception of nuclear risk was warped by fear of the communist threat.

President Truman recognized the need to direct nuclear knowledge towards peaceful, open pursuits, and in 1946 Congress set up the Atomic Energy Commission (AEC). Breaking the War Department's undemocratic control over the atom, the AEC institutionalized civilian authority over the development of both passive nuclear power and atomic weapons of war.

The decisions over the future of atomic science and technology now rested in civilian hands, but the risk of leaking America's nuclear secrets to Soviet spies quickly warranted maintaining nuclear secrecy. Trapped in a collective war mentality, the fear of subverting national security overwhelmed the drive to democratize nuclear knowledge. The federal government kept the details behind the US nuclear arsenal classified beyond top secret; authority over bomb design, testing, production, storage, transportation and deployment was limited to a handful of people in Washington. Citizens knew little about nuclear weapons outside their abstract capacity to end the world.

In a 1947 issue of *Harper's Magazine*, Secretary of War Henry Stimson published an article entitled "The Decision to Use the Atomic Bomb," explaining how the US government came to make and use nuclear weapons. Four months before bombing Japan, Secretary Stimson and President Truman had met to discuss the consequences of the Manhattan Project's imminent success. While they were confident no other nation would develop nuclear weapons technology for "some years," the simplicity of the science and the pace of technological innovation meant that the US wouldn't remain the sole nuclear power for long.[45] The likely proliferation of nuclear weapons left them entertaining the legitimate possibility of catastrophic nuclear war: "The world in its present state of moral advancement compared with its technical development would be

[45] Henry L. Stimson. "The Decision to Use the Atomic Bomb." *Harper's Magazine*. (February 1947).

eventually at the mercy of such a weapon. In other words, modern civilization might be completely destroyed."[46]

The most articulate broadcasters of nuclear risk were former Manhattan project scientists who clearly understood the bomb's destructive potential and took direct action to inform the public. Physicists Eugene Rabinowitch and Hyman Goldsmith founded the *Bulletin of the Atomic Scientists*, a forum for scientists and policymakers on the bombs implications for policy, war and human survival. In a February 1947 piece titled "How Dangerous Are Atomic Weapons?" Edward Teller looked critically at the expected consequences of an atomic World War III. While it would be possible to plan for and survive the initial explosion of even 10,000 Hiroshima sized bombs, sufficient radioactive contamination would leave the US and planet earth ecologically uninhabitable. As Teller wrote, the obvious "tolerance limits of living tissue for radioactivity… may help us to realize more clearly the probable consequence of an atomic war for our civilization and the possible consequence for the whole human race."[47] On the cover of its June issue, the *Bulletin* featured a symbolic clock face, set at seven minutes to midnight.[48] The Doomsday Clock, as it came to be known, represented how close humankind and planet earth were to nuclear catastrophe, and marked one of the first attempts to publicly monitor existential risks.

- Perspective

Watching America rise to the challenge of constructing the postwar world order, a young Massachusetts Representative immediately recognized the risk posed by nuclear weapons. In a

[46] Ibid.
[47] Edward Teller. "How Dangerous Are Atomic Weapons?"
[48] Ibid.

speech before the House of Representatives on April 1, 1947, John F. Kennedy warned the public:

> "The greatest danger is a war which would be waged by the conscious decision of the leaders of Russia some 25 or 35 years from now. She will have the atomic bomb, the planes, the ports, and the ships to wage aggressive war outside her borders. Such a conflict would truly mean the end of the world, and all our diplomacy and prayers must be exerted to avoid it."[49]

Returning from World War II a war hero, Kennedy was voted into office in 1946 as a Representative from Massachusetts. Kennedy's experience fighting in the Pacific theater had left him with a deep and largely cynical impression on organized conflict in general. "You know the military always screws up everything," he told journalist Robert Donovan. [50] While commanding a PT-109 boat in the Solomon Islands, he saw how the high level decisions made in Congress and the Oval Office translated to horror on the ground. As he wrote to his Danish lover Inga Arvad:

> The war here is a dirty business… We get so used to talking about billions of dollars, and millions of soldiers, that thousands of casualties sound like drops in the bucket. But if those thousands want to live as much as the ten [on my boat], the people deciding the whys and wherefores had better make mighty sure that all this effort is headed for some definite goal, and that when we reach that goal we may say it was worth it, for if it isn't the whole thing will turn to ashes, and we will face great trouble in the years to come after the war.[51]

From his front row seat in Congress, Kennedy watched the Cold War evolve out of World War II and escalate into the nuclear arms race. A strong supporter of spreading democracy and containing communism, he voted for the Marshall Plan to rebuild Europe and backed

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[49] John F. Kennedy. "Aid for Greece and Turkey." *Record of the House of Representatives*. April 1, 1947. Found in Sheldon M. Stern. Pg. 40.
[50] John F. Kennedy to Rose and Joseph Kennedy, May 14 and September 12, 1943. Personal Correspondence. Found in Sheldon M. Stern. *Averting "the Final Failure": John F. Kennedy and the Secret Cuban Missile Crisis Meetings.* (Stanford University Press: Stanford, 2003). Pg. 38. See also: Herbert S. Parmer. *Jack: The Struggles of John F. Kennedy*. (New York: Double Day, 1980). Pg. 111-12.
[51] Richard Reeves. *President Kennedy: Profile of Power.* (Simon & Schuster: New York, 1994). Pg. 139.

sending aid to Korea to keep the dominoes from falling red side up.[52] He vehemently believed in extending the American standard of living to the rest world, and had no qualms engaging in limited conflicts and subverting foreign governments to check Soviet power.

However Kennedy also recognized that nuclear weapons changed war completely. Familiar with the writings of Clausewitz, Mahan and other great warfighters of old, he understood the pattern of military innovation, and could tell that nuclear weapons were the end of the line in terms of strategic destruction. A war that exploited atomic technology to its full extent would bring the end of both aggressors. Kennedy saw the futility of fighting a total nuclear war, and knew that a human-induced apocalypse would not be intentional, but the terrifying consequence of accident, miscalculation, madness, or a mix of the three.

Although Kennedy was steeped in the politics of the new atomic age and the rising Soviet threat, he was not yet President, and carried relatively little influence in provoking or preventing World War III. His values, concerns, and hopes for the world crystallized against the backdrop of a nation trying to prevent nuclear Armageddon at the same time as they made it possible. His perception of nuclear risk was framed by scientific discovery, political debate, and public protest. By the time he took office, he had little hope that anyone could survive a post-nuclear world. As Kennedy grew aware of the known and unknown consequences of total nuclear conflict, he tried to minimize the possibility that it could ever happen.

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[52] *CQ Fact Sheet on John F. Kennedy,* (Congressional Quarterly: Washington D. C., 1960). Found in: "John F. Kennedy's Voting Record and Stands on Issues." *John F. Kennedy Presidential Library and Museum.* <http://www.jfklibrary.org/Research/Ready-Reference/JFK-Miscellaneous-Information/Voting-Record-and-Stands-on-Issues-Page-6.aspx>

Constructing the Cold War

"The fundamental antagonisms between Russia and the U.S. are so great that no settlement can ever really be reached. Ultimately, if the historic conditions for war are present, the Big Tow, will fight – and use the bomb. True, the A-bomb is a frightful weapon. But the past has shown us that the invention of new weapons has never in one single instance acted as a deterrent to war."[53]

- Fear

Pushed into the atomic age, Americans did two things with nuclear weapons: they worried about them, and they made more. While the public recognized the apocalyptic risk of nuclear conflict, whatever sense of caution towards mass-producing nuclear weapons was quickly overshadowed by the growing Soviet threat. In April 1949, the US, France, the UK, Canada, and others then signed the North Atlantic Treaty, "balancing" against the Soviet Union with the collective defense system NATO. Four-months later, the USSR detonated its first atomic bomb. The successful Soviet test on August 25, 1949 shattered Washington's assumption that nuclear weapons lay "beyond Soviet capacity in *any* time scale likely to be of much concern."[54] The hand of the *Bulletin's* Doomsday Clock swung from seven to three minutes till midnight, reflecting the world's incremental progress towards collective annihilation.

For most people reading the news, Russia's successful nuclear test meant only one thing: the US was no longer secure. As the world's sole post-war nuclear power, Americans reveled in the prospect of leading a new era of global peace and prosperity. With the benevolent expansion of free trade and democracy, the world would flourish under their responsible nuclear stewardship. The detonation of a Soviet atomic bomb crushed that possibility. Framed by the growing ideological battle between communism and the free world, the Soviet nuclear program directly threatened US national security. The public jumped at the chance to expand America's

[53] "Explosion!" *The New York Times*. September 25, 1949.
[54] Norman Polmar and John D. Gresham. *DEFCON-2: Standing on the brink of nuclear war during the Cuban missile crisis.* (John Wiley & Sons: Hoboken, 2006). Pg. 231.

nuclear weapons program, believing that a strong nuclear arsenal was the only safeguard against imminent attack. The Berlin Airlift and the Korean War proved the Soviet's intentions to expand and conquer, and many US citizens believed that the USSR intended to annihilate them and the world if the US didn't take action. Facing an aggressive and unreasonable Kremlin, many Americans viewed nuclear weapons as the solution to preventing Armageddon. As William Laurence wrote in his 1950 book *The Hell Bomb*:

> Let us therefore be done with all visionary plans for destroying the shield that now protects civilization as we know it, and proceed to build bigger and better shields, hoping that by our very act of doing so we can prevent the ultimate cataclysm. Right now the outlook is not bright, but our strength, physical and spiritual, will prevail in the end over the forces of evil, as they have always done throughout history; that the four freedoms will triumph over the Four Horsemen of the Apocalypse.[55]

With the Soviet's successful atomic detonation, the two superpowers plunged head first into the nuclear arms race. Firmly entrenched in an ideological struggle for global influence, the US government carried no idealistic expectations of peace. In a report to the Joint Chiefs of Staff, the Joint Intelligence Committee predicted that the Soviet Union would build enough nuclear weapons to attack the US and that they "may attack… at the earliest possible moment… at any time they assessed that it was to their advantage."[56]

The US immediately increased defense spending, and Americans prepared to fight, survive, and win a nuclear World War III.[57] In January 1950, Truman approved research and development of the hydrogen bomb, a weapon that would make the bombs of Hiroshima and Nagasaki look like firecrackers.[58] Unconfined to the physical limitations of earlier atomic

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[55] William L. Laurence. *The Hell Bomb.* (Alfred A. Knopf: New York, 1951). Pg. 70.
[56] "Implications of Soviet Possession of Atomic Weapons." A report by the Joint Intelligence Committee to the Joint Chiefs of Staff. JCS 2081/1, Feb. 13, 1950, CCS 471.6 U.S.S.R. (11-8-49), section 1, Papers of the United States Joint Chiefs of Staff. See also: Fred Kaplan. *Wizards of Armageddon*. (Simon & Schuster: New York, 1983). Pg. 39.
[57] Norman Polmar and John D. Gresham. Pg. 232.
[58] Edward Zuckerman. *The Day After World War III*. (The Viking Press: New York, 1984). Pg. 79-80. The atomic bombs dropped on Japan derived their explosive power from a single fission reaction, splitting uranium or plutonium nuclei to release a tremendous amount of energy. Pure-fission atomic bombs have a maximum yield of

weapons, the potential energy of an H-bomb lay "outside human experience and beyond human imagination."[59] Its implications for war and human survival had left the Atomic Energy Commission's General Advisory Committee, chaired by Robert Oppenheimer, unanimously opposed to its creation.[60]

The hydrogen bomb completely transformed US military strategy, "changing everything about the process of human violence called war."[61] Since the Trinity test, RAND systems analysts had begun integrating atomic bomb strikes into US war-fighting doctrine, searching for the most effective, rational approach to winning a nuclear conflict. While the A-bomb offered its keeper a degree of power never before imagined, by 1949, the United States had slightly fewer than 300 of them.[62] Limited plutonium and uranium resources meant that the Pentagon still had to choose the "correct" targets if they wanted to win a nuclear war. While bombing cities might destroy a nation's will to fight, it wouldn't destroy its capacity: its troops, ships, tanks, planes, and most importantly, its nuclear weapons. As Bernard Brodie, the chief civilian architect of US deterrence policy, wrote in 1950, an atomic-bombing campaign that quickly degenerated "into pure terroristic destruction" of cities would be "a military failure as well as a moral one."[63] With 300 atomic bombs, target discrimination, accuracy, *strategy* still mattered.

However, the successful detonation of the H-bomb "Mike" on Halloween 1952 ended any need to consider such questions. The 10.4-megaton bomb was twice as powerful as all of the

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about 500 kilotons, because "as soon as you assemble a critical mass of uranium or plutonium it will ignite whether you want it to or not." While the basic A-bomb involves one fission reaction, the hydrogen bomb works through a fission-fusion-fission process. The energy released from splitting uranium or plutonium nuclei causes deuterium and tritium nuclei in the H-bomb's core to fuse, generating inconceivable amounts of energy. This fusion reaction sets off another fission explosion in the bomb's uranium shell. There is no limit to the size of a hydrogen bomb, since "before firing that trigger, you can load the bomb with all the hydrogen in the world if you want to."

[59] Dee Garrison. *Bracing for Armageddon: Why Civil Defense Never Worked*. (Oxford University Press: New York, 2006). Pg. 22.

[60] Edward Zuckerman. Pg. 80

[61] Dee Garrison. Pg. 22.

[62] Fred Kaplan. *Wizards of Armageddon*. (Simon & Schuster: New York, 1983). Pg. 39.

[63] Bernard Brodie. "Strategic Bombing: What It Can Do." *The Reporter*. August 15, 1950. Found in: Frank Kaplan. Pg. 38.

explosives used in World War II, and vaporized the island of Elugelab in a blast that would have easily obliterated all five boroughs of New York City.[64] The incomprehensible power of the hydrogen bomb meant that it could miss its mark by miles and still successfully eliminate any strategic target in the area. More importantly, its simple design ended any worry that a scarcity of fissionable materials would limit nuclear weapons production. By 1952, it was clear "that the United States would have an abundance of bombs and materials with which to manufacture more."[65] As Brodie realized, the "art or science" of war now came not in finding out what to hit, but "what *not* to hit."[66] The Soviet Union detonated its first H-bomb in August 1953, and the hand of the Doomsday Clock ticked one minute closer till midnight, the closest it would ever be.

- Deterrence

Taking over the presidency less than three months after the first hydrogen bomb test, President Eisenhower clearly understood that the H-bomb brought an entirely new logic to geopolitics. First, Eisenhower knew that a strategic nuclear force would be vastly more cost-effective in checking the USSR than conventional military might, especially in Europe, where Soviet ground forces far outnumbered those of the US.[67] As he wrote in his memoires, "it seemed clear that only by the interposition of our nuclear weapons could we promptly stop a major Communist aggression in that area."[68] Eisenhower's "New Look" on national security, mapped out in the National Security Council report NSC 162/2, called for an increasing reliance

[64] Dee Garrison. Pg. 19-20.
[65] Frank Kaplan. Pg. 85.
[66] Bernard Brodie. "Changing Capabilities and War Objectives." Lecture, Air War College, April 17, 1952. Found in: Fred Kaplan. Pg. 79.
[67] McGeorge Bundy. Pg. 247.
[68] Dwight D. Eisenhower. *White House Years: Waging Peace, 1956-1961*. (Double Day: New York, 2000). Pg. 453. Found in: McGeorge Bundy. Pg. 248.

on nuclear weapons to contain communism, meet the US's international commitments, and cut defense spending.[69]

Second, Eisenhower recognized that it would soon be possible to deliver, in a single air offensive, enough explosive yield to vaporize every major military, industrial and population center in a nation, effectively wiping it off the face of the earth. Therefore, when considering US national security, "priority must be given to meeting the atomic threat, the only kind of attack that could, without notice, endanger our very existence."[70] The only effective means of deterring such an attack, as his Secretary of State, John Foster Dulles, explained, was maintaining "a great capacity to retaliate, instantly, by means and at places of our choosing."[71] Under Eisenhower's doctrine of "massive retaliation," the US expanded its nuclear arsenal from around 1,000 weapons in 1953, to over 18,000 by 1961.[72] The nuclear bomb became the only functional deterrent to the nuclear bomb.

The job of designing an effective US nuclear strike force was left to General Curtis LeMay and his Strategic Air Command (SAC). In World War II, LeMay had become a key architect of strategic bombing, first commanding B-17s in the European theater and later leading the B-29 bomber force in the Pacific.[73] An aggressive commander, LeMay orchestrated the devastating fire bombings of Tokyo, believing that "the whole point of strategic bombing was to be massive, a campaign of holy terror."[74] Haunted and driven by the memory of Pearl Harbor, LeMay strove to design a strike plan that would completely destroy the USSR's ability to wage

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[69] Peter J. Roman. "Ike's Hair Trigger: U.S. Nuclear Predelegation, 1952-1960." *Security Studies*, 7:4 (1998). Pg. 121-164.
[70] Ibid.
[71] John Foster Dulles. Speech. Council on Foreign Relations, January 12, 1954. *Documents on American Foreign Relations* (1954). Pg. 7-15.
[72] Peter J. Roman.
[73] Norman Polmar and John D. Gresham. Pg. 234.
[74] Fred Kaplan. Pg. 43.

war in a matter of hours.[75] Not one for restraint, his original strategy, SAC Emergency War Plan 1-49, consisted of 133 atomic bombs dropped on seventy urban targets over thirty days, in a "single massive attack."[76]

Over the course of nine years, LeMay transformed the SAC into the most devastating delivery service in human history. He quickly phased out the original SAC aircraft, replacing them with over 1,000 jet powered nuclear capable B-47 bombers by 1953.[77] With the introduction of the KC-97 Stratotanker in 1954, the dream of in-flight refueling became a reality, allowing bombers to stay on airborne alert indefinitely and immediately deploy to any target around the world. In June 1955, SAC received its first eight-jet B-52 heavy bombers, capable of carrying up to four megaton-yield bombs over an unrefueled flight radius of 3,000 miles.[78] By 1959, SAC manned a bomber fleet of 500 B-52s, more than 2,500 B-47s and over 1,000 tanker aircraft.[79] As the bomber force expanded, so did the SAC's target list, growing to cover more than 3,000 military, industrial, and population centers across the Sino-Soviet bloc.[80] Capable of unleashing more than 20,000 megatons of explosive on any (or every) target in the world, the SAC marked a degree of destructive power incomparable to any history had ever seen.[81]

LeMay also succeeded in shifting control of almost all stockpiled nuclear weapons from civilian to military hands. President Truman had placed nuclear technology under the custody of the AEC immediately after World War II, but LeMay and others worried that in a crisis, the time needed to find, transport, and load the bombs onto the aircraft could spell the difference between

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[75] Norman Polmar and John D. Gresham. Pg. 234.
[76] David Alan Rosenberg. "American Atomic Strategy and the Hydrogen Bomb Decision." *The Journal of American History*, Vol. 66 (1) (June, 1979). Pg. 62-87.
[77] David Alan Rosenberg. "The Origins of Overkill: Nuclear Weapons and American Strategy, 1945-1960."
[78] Ibid.
[79] Ibid.
[80] David Alan Rosenberg. "The Origins of Overkill: Nuclear Weapons and American Strategy, 1945-1960."
[81] McGeorge Bundy. Pg. 320.

survival and extermination.[82] Understanding the need to "decrease the vulnerability of the stockpile through dispersal and to increase operational readiness," President Eisenhower began transferring the warheads into military custody in June 1953.[83] By 1961, less than 10 percent of the stockpile remained under direct civilian control.[84] He also gave specific commanders, including LeMay, pre-delegated authority to use nuclear weapons, first against any attacking Soviet forces, and later in retaliatory strikes against the Soviet homeland.[85] As a memo on one of their meetings explained, "Strategic Air Command retaliation for any attack on the United States will be on the order of the President except in circumstances where communications between the President and the Commander of SAC is impossible because of the results of enemy attack."[86]

The SAC was cocked and ready for nuclear war. LeMay had no sense of the global environmental consequences of his war plan, nor did he care. His job was making sure that any nuclear attack on American soil would guarantee massive retaliation. For deterrence to work, the Soviets had to be certain that if they ever decided to bomb the US, they would all die.

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[82] Norman Polmar and John D. Gresham. Pg. 235.
[83] David Alan Rosenberg. "The Origins of Overkill: Nuclear Weapons and American Strategy, 1945-1960."
[84] Ibid. See also: "History of the Custody and Deployment of Nuclear Weapons: July 1945 through September 1977." *Office of the Assistant to the Secretary of Defense (Atomic Energy)*. Washington D.C., February 1978.
[85] Peter J. Roman.
[86] Robert R. Bowie and Gerard C. Smith. "Memorandum for the Secretary; Subject: Policy Regarding Use of Atomic Weapons." (May 15, 1957). Found in: *U.S. Nuclear History: Nuclear Arms and Politics in the Missile Age, 1955-1968*. (National Security Archive:

Apocalyptic Imaginings

> "If the United States or humanity is preparing to commit suicide it should do so with its eyes open and not by discovering too late that the fatal poison has been breathed."[87]

- Cobalt war

While the SAC was busy constructing the conditions for nuclear extinction, scientists and citizens contemplated living in a world wrecked by total nuclear war. The exact effects were impossible to calculate, as the critical information on arsenal sizes, explosive yields, remained hidden. Early civil defense measures - the alarms, informational pamphlets, public service announcements, and "Duck and Cover" videos – gave them a sugarcoated idea of a nuclear war, but as scientists, politicians and newscasters contemplated the full destructive potential of atomic energy, the physics of extinction was inescapable. As citizens came to grasp that human beings now had the technological capacity to eliminate themselves from planet earth, they began to question the logic of massive retaliation and resist a national security strategy that was based on imminent global suicide.

Although the blast and fire damage of nuclear weapons were severe, the most devastating effect of a hydrogen bomb was nuclear fallout. While the immediate explosions of an attack could conceivably be endured, the long-term radioactive fallout would be undeniably catastrophic. The end of the world would come not from flames, but from dust. At a University of Chicago "Round Table" broadcasted over NBC in February 1950, Leo Szilard and three other Manhattan project scientists introduced the concept of the cobalt bomb.[88] The most efficient way to extinguish the human species, they explained, would be to coat a hydrogen bomb with cobalt. The radioactive contamination from a typical H-bomb is relatively short-lived, but if coated with

[87] Gerald Wendt. Pg. 152.
[88] Gerald Wendt. *Atomic Energy and The Hydrogen Bomb*. (Medill McBride: New York, 1950). Pg. 149.

cobalt and detonated in the atmosphere, the bomb would release the radioactive isotope cobalt-60. Cobalt-60 has a half-life of five years – "short enough to be intensely radioactive yet long enough to remain lethal while it is spread over most of the earth by the gradual process of global fallout."[89] A "rigged" or "salted" cobalt bomb would virtually guarantee the contamination of the entire surface of planet earth.[90] All the ecological systems that Americans depended on would be laced with fatal radiation.

The cobalt bomb concept provided the first piece of open evidence that human extinction could be designed and decided. "Scientists Warn of World Suicide," reported *The Los Angeles Times (LAT)*, while an *NYT* headline read "Ending of All Life by Hydrogen Bomb Held a Possibility."[91] Szilard's thought experiment clearly showed how, if a nation wanted to, it could end life on planet earth relatively easily. The physics and chemistry behind it was simple; all it would take was the resources, time, and will.

For scientists and concerned citizens, the cobalt bomb proved that the era of total war was over. Weapons innovation had reached the end of line in terms of strategic destruction. As one editorial reflected:

> Throughout history men have made constant progress in their grim business of killing their fellows; as the generations have gone by they have been progressively able to kill more people with less work… We shall not stop with the A-bomb of Hiroshima, Nagasaki or Bikini. If war continues the time will surely come – ten years from now or a century or more from now – when all organized life on earth can be wiped out.[92]

With nuclear weapons, nations could not mobilize their "military, economic and human resources" against an enemy to "the maximum extent possible" without creating the conditions

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[89] Edward Zuckerman. Pg. 86.
[90] William L. Laurence. *The Hell Bomb.* (Alfred A. Knopf: New York, 1951). Pg. 70.
[91] "Scientists Warn of World Suicide." *The Los Angeles* Times. February 27, 1950. William Laurence. "Ending of All Life by Hydrogen Bomb Held a Possibility." *The New York Times*. February 27, 1950.
[92] "World's End – Maybe." *The New York Times.* February 28, 1950.

for mutual annihilation.[93] If the US or the Soviets exploited atomic technology to its full destructive potential, they would swiftly leave the planet uninhabitable. Considering the implications for military strategy, Szilard reflected,

> Suppose we have a war, and suppose that we are at the point of winning the war against Russia, maybe after a struggle which lasts ten years. Russia's leaders then say: "You come no further, you don't invade Europe… or else we detonate our H-bombs and kill everybody." Facing such a threat, I don't think we can go forward.[94]

The possibility of extinction through decision-making sparked widespread concern. As media coverage of America's atomic project grew, the public began to consider the implications. The first nuclear weapons test was broadcasted on television in April 1952, giving American's a powerful visualization of nuclear risk. The scale of devastation left by just one bomb was mind-blowing. It wasn't difficult to imagine how enough nuclear weapons could end the world in flames. However, American citizens had no control over the US nuclear program. For many, the fact that their fate was in hands of a few men they never met left them cynical or apathetic.

Although many scientists, citizens, and policymakers considered nuclear weapons capable of global annihilation, the federal government made little effort to investigate the long-term ecological effects of a total nuclear war. Instead, military planners viewed the bomb as a "psychological weapon," developed "to make sure no enemy will use it, and that, in that case, we will not use it."[95] Applying game and theory, they built complex models of nuclear confrontation to measure the Soviet threat.[96] Conditioned by the ideological struggle of the Cold War, experts from SAC and the RAND Corporation viewed nuclear weapons and their effects from the narrow perspective of strategic deterrence.

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[93] Sheehan, Micheal. "The Evolution of Modern Warfare." In *Strategy in the Contemporary World*, edited by John Baylis, James J. Wirth, and Colin S. Gray. (Oxford University Press: London, 2007). Pg. 54.
[94] William Laurence. "Ending of All Life by Hydrogen Bomb Held a Possibility."
[95] Gerald Wendt. Pg. 153.
[96] Barry Buzan and Lene Hansen. Pg. 89. See also Ole Wæver and Barry Buzan. "After the Return to Theory: The Past, Present and Future of Security Studies." In *Contemporary Security Studies*, edited by Alan Collins. (Oxford University Press: Oxford, 2007): 383-402.

The entire US national security strategy rested on maintaining a strike force capable of delivering massive nuclear retaliation in the face of any communist attack. Military strategists continually updated the list of sites programmed for bombing, adding airfields, shipyards, submarine bases, and factories as they found them.[97] Calculating the probability of a successful strike, war planners only accounted for the effects of the initial nuclear blast. Leaving out heat, fire and radiation damage, they drastically underestimated the damage done by each bomb. Overstating the number of weapons needed per target, the SAC adopted a strategy of overkill.[98] To guarantee target destruction, important sites would be "laid down" with multiple bombs, almost all of them "several megatons in explosive power."[99] Lost in the math of deterrence, security experts paid little attention to the broader, longer-term risks that came from a total nuclear war as they planned it.

In 1954, Assistant Secretary of Defense Donald Quarles confirmed that the cobalt bomb could be built, but would not be effective as a weapon, for obvious reasons.[100] The gap between military strategy and civilian science had become so large that the two were completely incompatible. Civilian scientists discussed how the cobalt bomb represented humanity's newfound capacity for self-extinction, but security analysts dismissed such concerns as strategically senseless. Meanwhile, the SAC turned the US atomic arsenal into the most devastating military machine of all time, ignoring the global implications of massive retaliation as they strived to keep America's deterrent credible. By the late 50s, LeMay's SAC could turn

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[97] Counterforce was introduced partially to revise LeMay's massive first strike plan and develop a "city-sparing" nuclear strategy. If the US could successfully take out enough of the Soviet's military capacity, then bombing population centers wouldn't be necessary. For more information, see: Charles H. Fairbanks, Jr. "MAD and U.S. Strategy." Henry D. Sokolski, Ed. *Getting MAD: Nuclear Mutual Assured Destruction, its Origins and Practice.* (Strategic Studies Institute: November 2004). Pg. 137

[98] Lynn Eden. *The Whole World on Fire.* (Cornell University Press: Ithaca, 2004). Pg. 120

[99] Fred Kapalan. Pg. 268. This was later referred to as "overkill."

[100] "Cobalt Bomb Declared Unpractical as Weapon." *The Los Angeles Times*. April 12, 1954.

the entire Sino-Soviet bloc into a radioactive wasteland in a matter hours. The US nuclear strike plan became, for all practical purposes, a cobalt bomb.

- Outcry

While the public was blind to the catastrophic actuality of the SAC strike plan, they were able to identify radiological contamination as an obvious existential hazard. Scientists had little concrete understanding of how radiation would circulate through the atmosphere, but it was clear that enough of it would leave earth uninhabitable. As the possibility of radiological warfare gained widespread attention, citizens realized the US government could never hope to fully protect them in the event of a nuclear war. While a strong atomic deterrent decreased the likelihood of an intentional Soviet attack, it increased the risk of leaving the entire earth uninhabitable after a nuclear conflict, and massive retaliation became more of a liability than a shield. The risk of global fallout cracked the military's logic of insuring peace by preparing for total nuclear war, and citizens began to demand test bans and disarmament.

Radioactive contamination became a real part of the public agenda in 1954, after the Castle Bravo test detonation covered 7,000 square miles of the Pacific Ocean (an area about the size of New Jersey) with radiation and killed one Japanese fisherman.[101] Democratic presidential candidate Adlai Stevenson made the issue of banning nuclear weapons testing part of his 1956 platform, arguing that the "poisoning of the atmosphere" threatened "the actual survival of the human race."[102] A year later, congressional hearings began on the biological effects of nuclear war and radioactive fallout, further solidifying public perception that nuclear conflict represented

[101] Edward Zuckerman. Pg. 84.
[102] Quoted in Ibid. Pg. 87.

a real, immediate, and massive risk.[103] In a hypothetical attack, "50 percent of existing dwellings in the United States would have been destroyed or rendered unusable for a period of several months."[104] While it was impossible to prove nuclear war would kill everyone, citizens could at least be sure that it would severely incapacitate the institutions critical to social coherence and survival. Following a total nuclear war, hospitals, industrial agriculture, water systems, roads, police, and government would all be left in ruins.

The obvious human capability to fight into extinction inspired a range of post-apocalyptic fiction that reflected the absurd futility of "preparing" for and "rebuilding" after a total nuclear war. Nevil Shute's best selling 1957 novel *On the Beach* depicted with deadpan realism how nuclear war would eventually kill everyone, without exception.[105] Set in Australia, a family watches the radioactive cloud from a massive exchange of cobalt-coated nuclear weapons slowly cover earth. The novel carried no distractions:

> … no invading aliens, no super-fallout shelters to protect the protagonists, no struggle back from a dreadful but exciting postwar barbarism… simply a man and a woman reaching the agonizing decision to kill their only child in its crib and commit suicide as the rest of the human race expires around them.[106]

Neville Schute's novel was a powerful reminder of the scale and intensity of nuclear risk. While others were not so brutally pessimistic, few could dream up a post-nuclear world that would actually be worth living in. One of the most widely read thinkers of the unthinkable was RAND's Herman Kahn. A key architect of nuclear war-fighting strategy, Kahn strove to better articulate and rationally weigh the probable outcomes of a nuclear World War III. His seminal

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[103] Chet Holifield. "Congressional Hearings on Radioactive Fall-out." *Bulletin of the Atomic Scientists*, Vol. 14 (1) (January 1958). See also: "Biological and Environmental Effects of Nuclear War." Hearings before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy. (Washington D.C.: June 22-26, 1959).
[104] "Biological and Environmental Effects of Nuclear War." Hearings before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy. (Washington D.C.: June 22-26, 1959).
[105] Paul Brians. *Nuclear Holocausts: Atomic War in Fiction, 1895-1984.* (Kent State University Press: London, 1987). Pg. 20.
[106] Ibid.

book, *On Thermonuclear War*, forced Americans to come to grips with the reality of a post-war world, which, while arguably survivable, would require extraordinary resilience in the face of unimaginable tragedy. In his vision of post-war policy, the more contaminated food would be fed to the elderly, as "most of these people would die of other causes before they got cancer."[107] Reflecting on the psychological limits of human resilience, he acknowledged that after a nuclear war, "Morale may be so affected that many survivors may refuse to participate in constructive activities, but would content themselves with sitting down and waiting to die."[108]

As they considered the brutal conditions of post-war existence, the public began to see any federal initiatives to "assure survival of a large part of the population in the event of an enemy attack" for what they really were, psychological pacifiers.[109] Medical supplies alone were "hopelessly inadequate," and even the most sophisticated shelter systems still couldn't guarantee that anyone would survive the lethal radioactive fallout, which could not only penetrate a house's roof but "work its way right down to the basement."[110] Civil defense manuals like "Facts About Fallout" and "The Family Fallout Shelter" tried to convince civilians that the problem of fallout "can be solved--as others have been--by American ingenuity and careful preparation."[111] But more than anything, they only proved the population's vulnerability. The US government could barely hope to survive, much less manage the outcome of an atomic exchange. The public began

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[107] Herman Kahn. *On Thermonuclear War.* (Princeton University Press: New York, 1960). Pg. 67. See also: Louis Menand. "Fat Man: Herman Kahn and the nuclear age." *The New Yorker.* (June 27, 2005). <http://www.newyorker.com/archive/2005/06/27/050627crbo_books?currentPage=all>

[108] Herman Kahn. Pg. 86. See also: Fred Kaplan. *Wizards of Armageddon*. (Simon & Schuster: New York, 1983). Pg. 227.

[109] "Survival Muddle: Civil Defense Planners Push Ahead Furiously – In Divergent Dirctions." *The Wall Street Journal*. February 12, 1958.

[110] Ibid.

[111] Federal Civil Defense Administration, "Facts About Fallout" (Washington, D.C.: U.S. Government Printing Office, 1955). See also: Edward Moore Geist. *Scenarios for Survival: Representations of Nuclear War in American and Soviet Civil Defense Manuals, 1954-1972.* University of North Carolina at Chapel Hill. Masters Thesis. 2008.

to recognize the danger of nuclear romanticism, and their cynicism towards civil defense laid the groundwork for the global anti-nuclear movement.

Eisenhower sympathized with Americans' opposition to any large investment in surviving a nuclear war.[112] His aversion to a comprehensive shelter system came in part from his conservative leanings, and in part from highly classified U-2 areal photos proving a massive US nuclear advantage over the Soviets. But Eisenhower also had a clear picture of how a total nuclear conflict would play out. Looking at RAND's war games, he considered any on-the-ground attempts to protect Americans from that risk as futile optimism. The Gaither Committee, a group of scientists and strategists Eisenhower commissioned to investigate the issue, concluded that civil defense would save lives not by providing an effective shelter system and realistic disaster plan, but by proving our preparedness to the enemy and "by reinforcing his belief in our readiness to use, if necessary, our strategic retaliatory power."[113] Eisenhower's nuclear security doctrine centered on preventing attack by guaranteeing a reply. Surviving a nuclear assault was only important insofar as it made America's deterrent credible.

By the end of his Presidency, Eisenhower understood the paradox. In a National Security Council meeting three days before Christmas 1960, he recognized that no one had any clear idea of a "probable" post-war world. "Perhaps after a nuclear attack we will all be nomads," he said.[114] Doubting that any stockpiles of food, water, or medical supplies would survive a sustained nuclear conflict, he concluded, "war no longer has any logic whatsoever."[115] Eisenhower had tried to engage Moscow in plans for comprehensive nuclear disarmament, but after a U-2 spy plane crashed Soviet borders, all constructive communication stopped. John F.

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[112] Dee Garrison. Pg. 86.
[113] Thomas J. Kerr. *Civil Defense in the U.S.: Bandaid for a Holocaust?* (Westview Press: Boulder, 1983). Pg. 108.
[114] Ibid.
[115] Memorandum. *NSC Series*, Box 13, Ann Whitman File, DDEL. (December 22, 1960). Found in: Dee Garrison. Pg. 102.

Kennedy, then the Democratic candidate running to replace Eisenhower, critiqued his misstep, saying he should have apologized for letting "the risk of war hang on the possibility of an engine failure."[116]

- Irreversible unknowns

Taking office in 1961, John F. Kennedy stepped up to the challenge of managing the most devastating military machine of all time. While in Congress, Kennedy had been steeped in the politics of nuclear deterrence, but the hard information – how many weapons we had, how many weapons they had, and how we would fight and win a nuclear war – had remained under the highest orders of secrecy. Now, as President, he had complete access to military intelligence, held total control over military engagement, and bore ultimate responsibility for the consequences.

Kennedy carried high hopes for a future of peaceful progress towards arms control, test bans, disarmament, and coexistence. However, his Vienna summit with Khrushchev in June 1961 proved that open and honest cooperation was a pipe dream. Khrushchev refused to discuss a nuclear test ban treaty without concrete plans for "general and complete" disarmament. Kennedy could not guarantee that, so he turned to the issue of Berlin.[117] As the summit drew to a close, Khrushchev presented Kennedy with an ultimatum: accept the USSR's plans to sign a peace agreement with East Germany in December, effectively driving the Western powers out of Berlin, or face confrontation.[118] War would take place "only if the US imposes it on the USSR," and force would be met with force.[119]

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[116] Ibid. Pg. 21.
[117] Michael R. Beschloss. Pg. 213.
[118] Ibid. Pg. 223.
[119] Ibid.

Leaving his first (and what would turn out to be his only) face-to-face meeting with Khrushchev, Kennedy remarked, "…it's going to be a cold winter."[120] Back on Air Force One, he vented to Kenneth O'Donnell: "it seems particularly stupid to risk killing a million Americans over an argument over access rights on an *Autobahn*... If I'm going to threaten Russia with a nuclear war, it will have to be for much bigger and more important reasons… the freedom of all Western Europe will have to be at stake."[121] When the Soviets divided Berlin with barbed wire and concrete two months later, Kennedy privately told his aides, "It's not a very nice solution, but a wall is a hell of a lot better than a war."[122] As the Berlin crisis of 1961 heated up, Kennedy prepared for an escalation into nuclear conflict.

Moscow's ultimatum forced the President to seriously consider the possibility of launching America's nuclear arsenal and starting World War III. On September 13, 1961 General Lyman Lemnitzer, the Chairman of the Joint Chiefs of Staff, gave him and his advisors – including Secretary of Defense Robert McNamara and General Maxwell Taylor – a full briefing on America's operative nuclear strike plans.

Under General Power's leadership, a team of security experts from RAND and SAC had joined all of the US nuclear weapons, including the Air Force's massive fleet of bomber aircraft and the Navy's growing stockpile of Polaris submarine-based missiles, into a unified attack strategy.[123] The formal attack plan, labeled the Single Integrated Operational Plan (SIOP-62), left McNamara disturbed by the "'fantastic' fallout and destruction it would produce."[124] General Power had never been one for restraint. A firm proponent of a nuclear first-strike, he once broke

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[120] Ibid. Pg. 224.
[121] Kenneth P. O'Donnell and David F. Powers. "*Johnny, We hardly Knew Ye": Memories of John Fitzgerald* Kennedy. (Little Brown: Boston, 1972). Pg. 292, 299-300.
[122] Ibid. 303. See also: Michael R. Beschloss. Pg. 278.
[123] David Alan Rosenberg. "The Origins of Overkill: Nuclear Weapons and American Strategy, 1945-1960."
[124] Ibid.

out in a December 1960 meeting: "Look. At the end of the war, if there are two Americans and one Russian, we win!"[125] William Kaufmann, the man giving the briefing, replied that Powers better make sure the two Americans were "a man and a woman."[126]

Designed for "execution in existing form, regardless of circumstances," SIOP-62 was a "blunt instrument" that provided the President with no flexibility to direct a "limited" nuclear attack on specific targets in particular areas of the world.[127] The Plan's sixteen strike options varied little; its rigid scope meant that not only Russia, but also China, North Korea, North Vietnam, and most of the Eastern European nations would be hit.[128] The country of Albania would be completely annihilated.[129] Moscow alone warranted twenty-three weapons on six different targets.[130] Leaving the Cabinet Room, the President reflected: "And we call ourselves the human race."[131]

While obviously concerned about the Soviet threat, Kennedy was aware that for now, the vast majority of the world's operational nuclear weapons were US made. A National Intelligence Estimate published in September 1961 "placed the number of Soviet ICBMs on launchers at only 10 to 25, with no marked increase considered likely during the immediately succeeding months."[132] General Power warned that "we had only 10% useable photographic coverage" of the USSR, allowing for the possibility of more ICBM pads, but the clearest intelligence

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[125] Fred Kaplan. Pg. 246.
[126] Ibid.
[127] William Y. Smith. "Memorandum for General Taylor: Strategic Air Planning and Berlin." *USAF*. (September 7, 1961). William Burr, Ed. *National Security Archive Electronic Briefing Book No. 56.* (September 25, 2001). <http://www.gwu.edu/~nsarchiv/NSAEBB/NSAEBB56/>
See also: Norman Polmar and John D. Gresham. Pg. 243.
[128] Ironically, Khrushchev had severed diplomatic ties with the Chinese, in part over Mao Zedong's reckless attitude towards nuclear war. For more information, see: Stewart Alsop. "Kennedy's Grand Strategy." *Saturday Evening Post* 235 (13) (March 31, 1962): 11-15.
[129] Michael Dobbs. *One Minute to Midnight: Kennedy, Khrushchev, and Castro on the brink of nuclear war.* (Alfred A. Knopf: New York, 2008). Pg. 28.
[130] Fred Kaplan. Pg. 268.
[131] Michael Dobbs. Pg. 228. See also: Richard Reeves. Pg. 229-30.
[132] Scott D. Sagan. "SIOP-61: The Nuclear War Plan Briefing to President Kennedy." *International Security* Vol. 12, No. 1 (Summer, 1987). Pg. 22-51.

supported that any "missile gap" was overwhelmingly in US favor.[133] High-level war games concluded that the Soviets could put "about 200 bombers over North America" in an unannounced first strike, but such an attack would be severely crippled by US air defenses.[134] If anyone could end the world, it was President Kennedy, tripping the switch on the most destructive war machine ever developed and patriotically marching into planetary suicide.

Kennedy had no illusions about the ability of the US to win a nuclear war. SIOP-62 was its own cobalt bomb, a single trigger that would destroy an entire continent and potentially eliminate the ecological systems on which the US depended. Dealing with the Berlin crisis, the President worried about being backed into a corner and forced to choose between protecting the freedom of Europe and risking global extinction.

With SIOP-62, this was the certain consequence of a war, the low bar in terms of what was at risk. The high bar, if the war continued past the initial strikes or if the thousands of explosions had any unforeseen health or environmental consequences, was anyone's guess. The outcome, physically and politically, was incomparable to any in recorded human history; no one had ever blown up a continent before. "Successfully" carrying out the SIOP-62 strike plan would have altered the biosphere to such an extent that the long-term consequences were unknowable. Earth's ultimate capacity to support advanced life could only be confirmed once the dust settled. As Secretary of Defense Robert McNamara recalled, "I'm not interested only in probable risks. I'm interested in less than probable risks, if they may lead to disastrous consequences. That was what motivated me."[135] Worrying about probabilities gave way to worrying about possibilities –

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[133] C.V. Clifton. "Memorandum of Conference With President Kennedy." *USAF*. (Washington D.C.: September 20, 1961). William Burr, Ed. *National Security Archive Electronic Briefing Book No. 56.* (September 25, 2001). <http://www.gwu.edu/~nsarchiv/NSAEBB/NSAEBB56/BerlinC3.pdf>

[134] Ibid.

[135] Rober McNamara. Interview. May 21, 1987, Washington, D.C. In James G. Blight and David A. Welch. *On the Brink: Americans and Soviets Reexamine the Cuban Missile Crisis*. (Hill and Wang: New York, 1989). Pg. 192.

of a rogue submarine captain launching a missile at D.C., of the wind carrying lethal radiation from a full US strike across Western Europe, of something unforeseen, uncontrollable and irreversible happening.

Kennedy never had any intention to use the SIOP plan.[136] In an environment of uncertainty, having the decimation of a continent rest on a single yes or no question seemed ludicrous. Trying to manage the Berlin crisis, he realized that the real security challenge was not checking the communist menace, but mitigating the risk of a total nuclear war from breaking out inadvertently. The question, in Kennedy's mind, was never whether or not to pull the trigger, but how to prevent setting off a chain of events that would cause the trigger to be pulled, either by "accident, or miscalculation, or by madness."[137] The lives of millions of non-combatants rested on a single order, and once it was given – either by the President, or if he was incinerated in a strike on Washington, the surviving military command – there would be no going back. However a nuclear war might start, he considered himself responsible, and with SIOP-62, such a war would leave the survival of anyone anywhere impossible to secure.

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[136] In an interview years after the Cuban missile crisis, Robert McNamara reflected: "Now I know the SIOP called for a massive response and I also recall that the President said in his speech announcing the quarantine that we'd respond massively. No way we would have done that. But – and this goes to my main point – during the missile crisis we never even talked about it. Sure it was a low probability, as I've said. But if some damn Soviet second lieutenant had launched a missile and it destroyed, say, Atlanta, would we then have gone to an all-out nuclear war? I hope not. But we never discussed it. We should have, but we didn't." Robert McNamara. Interview. May 21, 1987, Washington, D.C. In James G. Blight and David A. Welch. *On the Brink: Americans and Soviets Reexamine the Cuban Missile Crisis*. (Hill and Wang: New York, 1989). Pg. 195.

[137] John F. Kennedy. "Address to the United Nations General Assembly." (September 25, 1961). *John F. Kennedy Presidential Library and Museum.* <http://www.jfklibrary.org/Asset-Viewer/Archives/JFKPOF-035-048.aspx>

On the Brink

"There is no doubt that the crisis was resolved because of fear of the adverse consequences of pushing it any further. Read Khrushchev. He was scared. Read Bobby's book. The President was scared, too."[138]

- Limits of control

A week after the SIOP-62 briefing, the President sent General Lemnitzer a list of questions about the US nuclear war plan, asking him to explain the likelihood of mounting a successful first strike against the USSR, the potential effectiveness of an alternative strike plan that didn't target cities, the need to apply multiple missiles to one target, and the danger of a false alarm. Under "Question 14," the President wrote: "I am concerned over my ability to control our military effort once a war begins. I assume I can stop the strategic attack at any time, should I receive word the enemy has capitulated. Is this correct?"[139]

The brutal rigidity of SIOP-62 left Kennedy obsessing over his ability to limit nuclear damage if a war ever did break out. In an interview with Stewart Alsop, published in a March 1962 edition of the Saturday Evening Post under the title "Kennedy's Grand Strategy," he discussed his priorities in what he considered a new and changed military environment:

> As late as 1954 the balance in air power, in the nuclear weapons, was all on our side. The change began about 1958 or 1959, with the missiles. Now we have got to realize that *both* sides have these annihilating weapons, and that changes the problem. Of course in some circumstances we must be prepared to use the nuclear weapon at the start, come what may – a clear attack on Western Europe, for example. But what is important is that if you use these weapons you have to control their use. What you need is control, flexibility, a choice…[140]

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[138] Robert McNamara. Interview. May 21, 1987, Washington, D.C. In James G. Blight and David A. Welch. *On the Brink: Americans and Soviets Reexamine the Cuban Missile Crisis*. (Hill and Wang: New York, 1989). Pg. 200.
[139] Maxwell D. Taylor. "Memorandum to General Lemnitzer." (Washington D.C.: September 19, 1961). *USAF*. William Burr, Ed. *National Security Archive Electronic Briefing Book No. 56.* (September 25, 2001). <http://www.gwu.edu/~nsarchiv/NSAEBB/NSAEBB56/BerlinC3.pdf>
[140] Stewart Alsop. "Kennedy's Grand Strategy." *Saturday Evening Post* 235 (13) (March 31, 1962): 11-15.

As the President came face to face with the prospect of triggering a global nuclear war, his priorities centered around redesigning the US nuclear war plan to keep human error from immediately incinerating hundreds of millions of people. Reacting to the near miss over Berlin, Kennedy ordered a major review and revision of SIOP-62. The new SIOP-63 strike plan, drawn up over the spring of 1962, allowed the President to choose between a variety of attack options, ranging from limited bombings of Soviet missile silos to massive retaliation against everything red. Commissioned with the objective to retain "U.S. military superiority to the enemy or any potential enemies, at any point during or after the war," SIOP-63 minimized collateral damage to "a level consistent with national survival and independence."[141] The plan gave Kennedy the nuclear flexibility he was searching for. He would no longer be forced to decide, as he had to with Berlin, whether to release the entire US nuclear arsenal in the event of a limited confrontation with the Soviet Union.

But it still couldn't bank against human error. In early 1962, Barbara Tuchman published her best-selling book, *The Guns of August*, which explained in detail how a series of misunderstandings caused the nations of Europe to initiate pre-designed war plans that marched them into World War I. Tuchman's main point was that, when triggered, the military deterrents each nation had put in place to prevent attack ended up launching them into a devastating conflict that no one had wished for or anticipated. Kennedy found Tuchman's investigation so compelling that he often quoted her, and had copies of her book sent to every US military base in the world because he wanted "every officer in the Army" to read and internalize it.[142]

Kennedy clearly understood the impossibility of maintaining executive control over the tens of thousands of nuclear weapons programmed for use if tensions got too high. In March

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[141] "History of the Joint Strategic Target Planning Staff: Preparation of SIOP-63." Strategic Air Command, History and Research Division. January 1964. Declassified February 2007.
[142] Richard Reeves. Pg. 306. See also: Michael Dobbs. Pg. 226.

1962, Thor and Jupiter missiles became fully operational in Turkey and Italy, capable of delivering bombs 100 times the yield of Hiroshima to Moscow in under twenty minutes.[143] A month later, Kennedy refused the Air Force's request to load high-yield thermonuclear bombs onto fighter aircraft deployed in Western Europe because they were not secured with locking systems to prevent unauthorized use.[144] Aware of the incalculable consequences of a nuclear war, Kennedy also understood the limits of his ability as commander in chief to retain absolute authority over each weapon in America's global nuclear umbrella.

Aside from the SAC's multi-megaton "theater" or "strategic" nuclear weapons, by the time SIOP-63 became operational in August, the US had thousands of "tactical" nuclear weapons ready for use in land, air, or sea combat. Carrying much lower yields than the customary nuclear bomb, tactical nukes came in all shapes and sizes: artillery shells, surface-to-air missiles, depth charges, anti-submarine rockets, submarine launched torpedoes, even a nuclear mortar for foot soldiers called the Davy Crockett.[145]

Both "strategic" and "tactical" weapons carried few controls other than the common sense of the people directly handling them. While the launch sequence of some of the larger missiles required two physically separated personnel to simultaneously turn a pair of keys, most were protected only by the Personnel Reliability Program, "a series of psychological tests and monitoring to certify that the individual handling nuclear weapons and their release were both responsible and emotionally stable."[146] President Kennedy's control over the entire US nuclear arsenal was ambiguous, and he knew it. All that was need was one anomaly in the plan to push

[143] Michael Dobbs. Pg. 234.
[144] Ibid. Pg. 250.
[145] Norman Polmar and John D. Gresham. Pg. 249.
[146] Ibid. Pg. 240.

the world over the brink. As the President worked to rein in the growing risk of a nuclear exchange, Khrushchev began quietly shipping Soviet nuclear missiles to Cuba.

The US intelligence community began catching wind of military activity on the island in late July, but most intelligence experts were still so caught up in the friction over Berlin that they initially dismissed any idea of a Soviet missile deployment in Cuba. The unusual level of Soviet aid frustrated those covertly working to overthrow Castro with economic and political sabotage, but the only strong voice of concern came from the CIA's director John McCone.[147] On August 30, photographs from a U-2 mission confirmed that eight SA-2 surface-to-air missile systems were almost operational and another sixteen were under construction.[148]

Kennedy worried about the build up, but after a U-2 spy plane accidentally crossed into Soviet airspace and another was shot down over China, he feared provoking an international crisis. A U-2 crash over Cuba would threaten negotiations over Berlin and undermine America's global image. In a meeting on September 10, Secretary of State Dean Rusk and National Security Advisor McGeorge Bundy recommended restricting U-2 reconnaissance flights to Cuba's periphery to avoid the SA-2s launch pads. "Everything should be done to minimize the risk element and avoid a third incident," they argued.[149] In one of the most fateful decisions of his presidency, Kennedy limited U-2 flights to international waters and the parts of Cuba still lacking SA-2 protection.

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[147] A long-time advocate for maintaining US strategic superiority, McCone had been a key political player in building the hydrogen bomb and firmly opposed nuclear arms control or a test ban treaty. He was highly suspicious of Moscow and supported using military force to intervene in Cuba before the USSR made it too costly. See: Alexandr Fursenko and Timothy Naftali. *One Hell of a Gamble: Khrushchev, Castro, and Kennedy*. (W. W. Norton: New York, 1997). Pg. 200.

[148] Norman Polmar and John D. Gresham. Pg. 77.

[149] Lyman Kirkpatrick. "White House Meeting on 10 September 1962 on Cuban Overflights." March 1, 1963. Found in McAuliffe, Mary ed. *CIA Documents on the Cuban Missile Crisis 1962*. (Central Intelligence Agency: Washington D.C., 1992). Pg. 61.

Kennedy's fear of increasing the risk of a global nuclear war drove him to stop U-2 over flights of Cuba. Intent on avoiding any action that could lead to direct military engagement with the USSR, his caution hogtied his intelligence team. For over a month, the CIA continued to receive evidence of a growing Soviet military presence, but without full photographic reconnaissance of the island, they could only speculate on the specifics. On October 9, Kennedy finally ended his moratorium on over-flights in response to mounting pressure from his intelligence advisors. Five days later, U-2 pilot Major Heyser returned from Mission 3101 with the photos that would change everything.[150]

- Crisis and decision

After a full night and day of examining and re-examining the film, the CIA confirmed that Soviet SS-4 medium-range ballistic missiles (MRBMs) had recently arrived in Cuba. Briefed in bed on the morning of October 16, the President scheduled an emergency national security meeting for later that day. The Executive Committee of the National Security Council (ExComm) became Kennedy's core group of military and civilian advisors. Reflecting his preferred style of counsel, ExComm was made up of highly competent and diversely opinionated men who could offer the President "the best range of ideas and concepts" to draw from when making his final decision.[151] Participants ranged from Assistant Secretary of Defense Paul Nitze, who helped write NSC-68 and led America's crusade against communism, to Theodore Sorensen, a conscientious objector in World War II. Meeting in the Cabinet Room, they began their first of many discussions on how the US should move forward after finding Soviet ballistic missiles in Cuba.

[150] Norman Polmar and John D. Gresham. Pg. 87.
[151] Ibid. Pg. 102.

As the crisis evolved, all the experts questioned their own advice, reconsidered their options, and shifted positions as they searched for the best course of action. However, certain voices were more consistent and articulate than others. The President's brother Robert Kennedy, along with McGeorge Bundy, Paul Nitze, John McCone, and Chairman of the Joint Chiefs of Staff Maxwell Taylor generally favored using military force to remove the missiles, whether through an airstrike, ground invasion, or both. Theodore Sorensen, Secretary of State Dean Rusk, and Under Secretary of State George Ball were more aware of the dangers of a direct military operation, and regularly advocated for a political approach.[152] Robert McNamara, Kennedy's close friend and Secretary of Defense, was the most articulate advocate for fully considering the consequences of their decisions. It was the President's burden to guide the discussion, weigh the options, and ultimately decide the US course of action.

ExComm immediately agreed to step up U-2 reconnaissance of the island, and soon turned to discuss how to react to the missiles. It was unlikely that any would be ready to fire "within a matter of hours, or even a day or two," but no one could be certain.[153] An airstrike could destroy them before they became operational, but once they were assembled it would be impossible to "knock them out before they can be launched. And if they're launched there is almost certain to be chaos in part of the East Coast."[154] On the back of the CIA memo prepared for the October 16 meeting was a map of the SS-4's range.[155] The missiles put the entire American southeast under the imminent threat of a nuclear strike, and Washington D.C. sat right

[152] For an overview of each major participant in the ExComm meetings, see: Sheldon M. Stern. Pg. 41.
[153] Timothy Naftali and Philip Zelikow. *The Presidential Recordings: John F. Kennedy Vol. 2, The Great Crisis.* (W. W. Norton: New York, 2001). Pg. 401.
[154] Ibid. Pg. 407.
[155] For a detailed recount of the photographic analysis and intelligence assessments that occurred throughout the crisis, see: Dino A. Brugioni. *Eyeball to Eyeball: The Inside Story of the Cuban Missile Crisis*. Robert F. McCort ed. (Random House: New York, 1990).

on the edge.[156] McNamara later explained, "All these things added up to one unequivocal conclusion… we had to force the missiles out of Cuba, without forcing the Soviets to respond in a way that could have led us all into disaster."[157]

There was no doubt that the weapons would have to be removed, one way or another, but Kennedy was obligated to consider the reverberating consequences of a blatant military assault. As Taylor and McNamara outlined the Pentagon's plans for an airstrike, naval blockade and ground invasion, ExComm discussed how any military operation wouldn't be the end, but likely the beginning of a chain-reaction that would affect all "points of vulnerability around the world," from Berlin to Korea.[158] McNamara wondered:

> Now after we've launched 50 to 100 sorties, what kind of a world do we live in? How do we stop at that point? I don't know the answer to this. I think tonight… we ought to work on the consequences of any one of these courses of actions, consequences which I don't believe are entirely clear to any of us.[159]

George Ball, who had surveyed the wreckage of Hiroshima and Nagasaki, jumped in, adding "at any place in the world." McNamara replied, "At any place in the world, George. That's right. I agree with you."[160] Kennedy's advisors were acutely aware of the unknown global consequences of nuclear war, and questioned any policy that would unnecessarily increase the risk of it breaking out.

The next day, the President left to campaign for the November congressional elections in Connecticut, determined to maintain his public schedule until he decided on a clear course of

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[156] "Probable Soviet MRBM Sites in Cuba." *CIA Memorandum*. October 16, 1962. Found in: McAuliffe, Mary ed. *CIA Documents on the Cuban Missile Crisis 1962*. (Central Intelligence Agency: Washington D.C., 1992). Pg. 61. See Appendix for the graphic.
[157] Robert McNamara. Interview. May 21, 1987, Washington, D.C. In James G. Blight and David A. Welch. *On the Brink: Americans and Soviets Reexamine the Cuban Missile Crisis*. (Hill and Wang: New York, 1989). Pg. 191.
[158] Timothy Naftali and Philip Zelikow. Pg. 467.
[159] Ibid. Pg. 448.
[160] Ibid.

action. Sometime that morning, he received a letter from the US ambassador to the UN, Adlai Stevenson, urging him to resist authorizing an airstrike:

> I know your dilemma is to strike before the Cuban sites are operational or to risk waiting until a proper groundwork of justification can be prepared. The national security must come first. But the means adopted have such incalculable consequences that I feel you should have made it clear that the existence of nuclear missile bases anywhere is negotiable before we start anything.[161]

While he was gone, ExComm continued to discuss, define, and prepare a number of response options, ranging from a public statement and ultimatum for removal to an immediate, full-scale armed assault on Cuba. Before they retired at midnight, Robert Kennedy summarized five general strategies:

1. An ultimatum to Khrushchev, followed by an air strike
2. Limited air strikes without prior warning or negotiation
3. Political warning, followed by a naval blockade, with notification to key allies
4. Large-scale air strikes after limited political preparation
5. Proceeding directly to an invasion, under the pre-designed war plans OPLAN 314 and 316[162]

Around 11:00 a.m. on Thursday morning, October 18, ExComm briefed Kennedy in the Cabinet Room. New U-2 photographic evidence proved that a limited air strike could no longer guarantee a solution to the missile threat in Cuba.[163] The pace and scale of the build-up was clear. Moscow intended to establish a major forward military base in Cuba, and the only way to insure all the missiles were destroyed would be to "take the island."[164] As General Taylor explained, "we can't prevent this construction going ahead by any air actions. Conceivably diplomatic action might stop it, but only diplomatic action, or occupation as far as I can see, can

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[161] Adlai Stevenson. Letter to President Kennedy. October 17, 1962. Found in: Laurence Chang and Peter Kornbluh, ed. (His underlining).
[162] Norman Polmar and John D. Gresham. Pg. 109.
[163] The photos confirmed that SS-5 intermediate-range ballistic missile launch sites (IRBMs) were in Cuba. The SS-5 installations were less complete than the SS-4 sites, but SS-5 missiles had twice the range, and once operational they would be capable of delivering far deadlier warheads to anywhere in the continental US. Reconnaissance also confirmed that IL-28 bomber aircraft, capable of carrying nuclear bombs, had also arrived.
[164] Timothy Naftali and Philip Zelikow. Pg. 529.

prevent this kind of threat from building up."[165] The US military would not be able to eliminate the missile threat without killing several hundred Soviet and Cuban citizens in what Ball called a "Pearl Harbor" airstrike, invading Cuba with little warning or negotiation and blatantly violating international law.[166]

Kennedy and his advisors quickly acknowledged that the broader political ramifications of such a knee-jerk response could be catastrophic. Following a US strike on Cuba, Khrushchev could easily justify overrunning US missile bases in Turkey and Italy, and if Soviet troops forced their way into Berlin, general war would be almost impossible to avoid. Entertaining such a scenario, McNamara wondered, "We have US troops there. What do they do?" General Taylor replied, "They fight." The Soviet's clear military supremacy around Berlin would mean that "they get overrun, exactly." Robert Kennedy asked, "Then what do we do?" Rusk jumped in: "You'd have to start at least with tactical nuclear weapons if [Khrushchev] tried to attack Berlin." Weighing the very real risk of military escalation, the President concluded, "Now, the question really is to what action we take which lessens the chances of a nuclear exchange, which obviously is the final failure. That's the obvious direction…"[167] Painfully aware of how quickly a military strike on Cuba could devolve into World War III, Kennedy was dedicated to exhausting all other options before authorizing an invasion that would put the entire world at risk.

The President never believed there was any chance of surviving a nuclear war. "They put [warheads] on cities," he said, "and you know how soon these casualty figures [mount up] – 80 million, whether it's 80 or 100 – you're talking about the destruction of a country."[168] While the

[165] Ibid. Pg. 529.
[166] Ibid. Pg. 539.
[167] Ibid. Pg. 541.
[168] Ibid. Pg. 590.

US still boasted overwhelming nuclear superiority on all levels, even without the missiles in Cuba, the Soviets "could kill."[169] In terms of mutually assured destruction (MAD), Kennedy believed that "they've pretty well got us there anyway."[170] If a single Soviet missile landed somewhere near an American city, the number of deaths could reach 600,000. "That's the total number of casualties in the Civil War," Kennedy reflected, "and we haven't got over that in a hundred years."[171] Even the most limited atomic war possible was an unacceptable risk. And once the first bomb fell, total war was almost inevitable. Under this logic, invading Cuba without giving Khrushchev "a way out" would be playing nuclear "Russian roulette."[172]

Kennedy clearly articulated the US course of action in an ExComm meeting on October 20. Accepting that there were no safe choices, the President authorized a naval blockade to prevent any new weapons from entering Cuba, to begin Wednesday, October 24, after a public statement to the nation on Monday, October 22.[173] Kennedy gravitated towards the naval blockade because it gave him the flexibility to follow up with immediate military action if diplomacy failed, but didn't slam the door on the possibility of a peaceful resolution. A blockade couldn't eliminate the missile threat, but then again, neither could an invasion. Instead, it would allow the President to stall a preventative attack and "avoid, if we can, nuclear war by escalation or imbalance."[174] Kennedy would keep the airstrike and ground invasion options ready for use if the need for decisive action arose. However, he was determined to accept direct military confrontation only as the last possible resort.

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[169] Ibid.
[170] Ibid.
[171] Richard Reeves. *President Kennedy: Profile of Power.* (Simon & Schuster: New York, 1994). Pg. 175.
[172] Timothy Naftali and Philip Zelikow. Pg. 568.
[173] "Minutes of the 505th Meeting of the National Security Council." October 20, 1962. Found in: Sheldon M. Stern. Pg. 133.
[174] Timothy Naftali and Philip Zelikow. Pg. 593.

The Joint Chiefs of Staff unanimously opposed the Presidents decision. They saw anything short of an immediate airstrike, blockade and invasion as "appeasement."[175] Arguing that the missiles in Cuba seriously affected the nuclear "equation" by giving the Soviet Union a more effective first strike, the Chiefs recommended a full invasion before it was too late. The US enjoyed a dramatic nuclear advantage over the USSR (seventeen to one), and Khrushchev would never enter a fight he was sure to lose. Thanks to the SAC, the US had the "Russian bear" in a trap.[176] The vulnerability of the Soviet forces "should have encouraged Kennedy to take larger risks than he did."[177] With characteristic belligerence, General LeMay proposed, "let's take his left leg off right up to his testicles. On second thought, let's take off his testicles too."[178] Decisive action in Cuba would only increase the credibility of the US deterrent, signaling to Khrushchev that any attempt to take Berlin would be treated with equal dispassion.

While the President respected the Joint Chiefs' advice, he found their risk assessment flawed and incomplete. Robert Kennedy would later write that his brother "was disturbed by this inability to look beyond the limited military field." The US national security apparatus fully trusted the logic of deterrence. They were convinced of the Soviet's intention to destroy the US in a first strike, and when the missiles appeared in Cuba, they focused exclusively on combating that threat. Certain that Cuba could be taken and that Moscow would not retaliate, they didn't consider the broader risks of military action. The Joint Chiefs trusted their intelligence and believed they could control how the dominoes fell in a full invasion.

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[175] Ibid. Pg. 583.
[176] Dino A. Brugioni. *Eyeball to Eyeball: The Inside Story of the Cuban Missile Crisis*. Robert F. McCort, ed. (Random House: New York, 1990). Pg. 469.
[177] Joseph Nye. Foreword to James G. Blight. *The Shattered Crystal Ball: Fear and Learning in the Cuban Missile Crisis*. (Roman & Littlefield: Maryland, 1990). Pg. xiv.
[178] Ibid.

But the fog of war was thick, and any direct engagement with Soviet troops in Cuba would cause a scale-of-magnitude spike in the risk of something going wrong. The Joint Chiefs did not consider the possibility that the Soviet force in Cuba had tactical nuclear weapons, which they did, or that they were ready to use them in the event of an invasion, which they were.[179] They also ignored the risk of the US nuclear chain of command from breaking down under stress. As plans for military engagement moved forward, Kennedy was adamant that "we've got to have some degree of control," and with so many moving pieces, he was painfully aware of how difficult that was.[180] If US boots hit the ground in Cuba, trying to manage the chain reaction that followed would be futile. As the President quipped, "These brass hats have one great advantage in their favor… If we listen to them and do what they want us to do, none of us will be alive later to tell them that they were wrong."[181] With enough friction, there would be a spark, and in October 1962, the whole world was a powder keg.

On Sunday, October 21, the President met with Ted Sorensen and ExComm to finalize preparations for the blockade and draft his Monday speech. As if he needed any more proof that a nuclear war was not survivable, a final update on civil defense measures revealed that emergency supplies of food, water and medicine had not yet made it to storage sites around the country.[182] The following afternoon, he placed all military personnel around the world on DEFCON 3 alert, two levels from imminent nuclear war. At 6:55 p.m. on October 22, Kennedy went on national television to announce the presence of Soviet offensive missiles in Cuba.

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[179] The US military consistently underestimated the size and capability of the Soviet force in Cuba. Had they proceeded with an airstrike and beach landing as planned, they would have surely walked into a tactical nuclear war that would have obliterated Guantanamo Bay and left few American invaders alive.
[180] Timothy Naftali and Philip Zelikow. Pg. 594.
[181] Kenneth P. O'Donnell and David F. Powers. *Johnny, We Hardly Knew Ye.* (Little Brown: Boston, 1970). Pg. 318. Found in Michael Dobbs. *One Minute to Midnight: Kennedy, Khrushchev, and Castro on the brink of nuclear war.* (Alfred A. Knopf: New York, 2008). Pg. 23.
[182] Sheldon M. Stern. Pg. 137.

Outlining his plan of action, he called on Khrushchev to "move the world back from the abyss of destruction" by immediately withdrawing the weapons and negotiating a peaceful solution.[183]

- Luck and survival

Kennedy's announcement that Soviet nuclear missiles were installed in Cuba left the American public in shock. The decision to go to nuclear war was the exclusive burden of the President. With little influence over their fate, many people had grown apathetic towards atomic holocaust. But the real possibility of waking up to a nuclear World War III shook the foundations of their indifference. American citizens glued themselves to their televisions, and all over the country people held their breath as the world hung in the balance. Some prepared for the worst, stocking up on food, water, and duct tapes, but most simply watched and hoped, knowing their future rested on the President's ability to remove the missile threat while avoiding the risk of outright war.

Once the missiles went public, time sped up. Bomber and interceptor aircraft were already on constant airborne alert, and the Army began shifting troops, ammunition, and supplies to military bases in the southeast. U-2 spy-planes flew low-altitude reconnaissance missions to guarantee accurate maps for airstrike and invasion plans. As allied nations and the domestic public came to grips with the crisis at hand, US warships, aircraft carriers and submarines moved to encircle Cuba. Soviet merchant ships steamed towards the quarantine line, showing no sign of slowing down or turning back.

ExComm continued to evaluate different courses of action, maintaining the Air Force and Army on high alert as the Navy prepared to blockade Cuba. Adlai Stevenson recommended

[183] John F. Kennedy. "Radio and Television Report to the American People on the Soviet Arms Buildup in Cuba." October 22, 1962. *John F. Kennedy Presidential Library and Museum.* <http://www.jfklibrary.org/Asset-Viewer/sUVmCh-sB0moLfrBcaHaSg.aspx>

taking Jupiter missiles out of Turkey and Italy in a negotiated trade. Stevenson later told White House Chief of Staff Ken O'Donnell, "I know that most of those fellows will probably consider me a coward for the rest of my life for what I said today, but perhaps we need a coward in the room when we are talking about nuclear war."[184] The military men found his proposal absolutely unacceptable, but Kennedy admired Stevenson's search for alternatives. The President asked the Joint Chiefs of Staff to make certain that American military personnel in Turkey and Italy would not launch their missiles without a direct presidential order, and that they dismantle the warheads to make an unauthorized launch impossible.[185] He refused to risk war over a few outdated weapons, and continued to consider a trade in the face of strong opposition from his advisers.

As the crisis escalated, the President watched his control over the events on the ground breakdown under the military momentum. ExComm reviewed the plans for intercepting, boarding and if necessary, sinking foreign ships, and on October 24, the blockade began. Kennedy knew he would never be able to direct battlefield decisions in real-time, and could never know how a physical confrontation would end. He obsessed over the risk that one unlucky clash could spark a war of global proportions in a matter of minutes, and over the next few days, that clash seemed inevitable.

Tensions reached their zenith on Saturday, October 27. Kennedy had received a hopeful letter from Khrushchev the day before promising to remove the missiles for a pledge not to invade Cuba. But a new letter now demanded the US remove their missiles from Turkey as a trade.[186] As ExComm deliberated Moscow's change of terms, a U2 spy-plane got lost over

[184] Michael R. Beschloss. Pg. 678-697.
[185] Michael Dobbs. Pg. 234.
[186] The Kremlin's new, more aggressive negotiating stance was in fact just a miscommunication. The letter demanding a trade was meant to arrive on October 26, and the more hopeful letter was dated for October 27, but the two got switched in transit.

Alaska and crossed into Soviet airspace. Both countries sent fighter jets to intercept it.[187] The US F-102s were armed with tactical nuclear warheads, and an interception would have surely meant a dogfight. Another U-2 pilot was not so lucky, and was shot down over Cuba that afternoon. The Joint Chiefs argued for immediate retaliation:

> At first, there was almost unanimous agreement that we had to attack early the next morning with bombers and fighters and destroy the SAM sites. But again the President pulled everyone back. "It isn't the first step that concerns me," he said, "but both sides escalating to the fourth and fifth step – and we don't go to the sixth because *there is no one around to do so.* We must remind ourselves we are embarking on a very hazardous course."[188]

Even after losing a US soldier to Soviet anti-aircraft guns, Kennedy strained to avoid direct military confrontation. However, he could only stall for so long. Off the coast of Cuba, the Navy was tracking down Soviet submarines in an advanced game of cat and mouse. From the White House, Kennedy listened to radio transmissions as US warships began dropping depth charges on a Soviet submarine to force it to surface.[189] Fearing the worst, he cried, "Isn't there some way we can avoid having our first exchange with a Russian submarine – almost anything but that?"[190]

The President knew he was running out of time. Black Saturday proved how inevitable a clash would be if the crisis continued much longer. With so many pieces in motion, the world's future was resting on little more than luck. Using his brother as a backchannel to contact Khrushchev, Kennedy secretly agreed to remove the missiles in Turkey once Moscow took the missiles out of Cuba. On Sunday morning October 28, the Kremlin publicly announced an immediate withdrawal of the Soviet military presence in Cuba. Kennedy and Khrushchev's

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[187] Norman Polmar and John D. Gresham. Pg. 8.
[188] Robert F. Kennedy. Pg. 76. My emphasis.
[189] At the time, the American military command was not aware that the submarine carried nuclear weapons. In one of the tensest moments of the crisis, two Soviet captains convinced their superior to refrain from launching their warheads. Fighting exhaustion and panic, they narrowly avoided a nuclear firefight with the US Navy.
[190] Robert F. Kennedy. Pg. 48.

mutual fear of nuclear war drove them to a diplomatic solution before a spark set the world on fire.

The President's decision to stall a US military invasion of Cuba and pursue a diplomatic solution was not surprising. His context and character inform how he perceived the risk of nuclear war, and how he responded to the Cuban missile threat. As a Representative and Senator for thirteen years, Kennedy watched the atomic age burst out of World War II and redefine international politics. He wasn't deaf to the decade and a half of discussion, research and policy surrounding nuclear technology, from the discovery of radiological side-effects to the H-bomb's implications for military strategy. The President never had any illusions about surviving, much less winning a total nuclear war. Once he took office, he struggled to keep control of the most devastating war machine of all time. When Soviet and US tanks faced off over Berlin, Kennedy grappled with the rigid SIOP-62 strike plan, finding it "insane that two men, sitting on opposite sides of the world, should be able to decide to bring an end to civilization."[191] Painfully aware of his direct responsibility for the outcome, he refused to back himself into a corner where he would be forced to push the button.

By the time missiles were discovered in Cuba, the President believed that any direct confrontation with the USSR would put all human life at risk by starting a war with no survivable end. While hard, climatic data did not yet exist to confirm any suspicions about long-term environmental damage, Kennedy was sure that once a total nuclear war began, it would destroy most of the institutions critical to social coherence, including hospitals, roads, water systems, police, government, industrial agriculture etc. He imagined a planet ravaged by 'fire,

[191] Quoted in Michael Dobbs. Pg. 229.

poison, chaos, and catastrophe," and refused to be the President that led humanity into that nightmare.[192] Robert Kennedy recalled:

> He wanted to make sure that he had done everything in his power, everything conceivable, to prevent such a catastrophe. Every opportunity was to be given to the Russians to find a peaceful settlement which would not diminish their national security or be a public humiliation. It was not only for Americans that he was concerned, or primarily the older generation of any land. The thought that disturbed him most, and that made the prospect of war much more fearful that it would otherwise have been, was the specter of the death of the children of this country and all the world – the young people who had no role, who had no say, who knew nothing even of the confrontation, but whose lives would be snuffed out like everyone else's.[193]

Kennedy's belief that nuclear war was a global existential risk drove him to avoid direct military engagement at all costs, buying Khrushchev and him the time to negotiate their way back from the brink. Despite their differences, both leaders recognized that their system of Mutually Assured Destruction (MAD) was fragile. Jackie Kennedy wrote to Khrushchev after her husband's assassination, reflecting:

> You and he were adversaries, but you were allied in a determination that the world should not be blown up. The danger which troubled my husband was that war might be started not so much by the big men as by the little ones. While big men know the need for self-control and restraint, the little men are sometimes moved more by fear and pride.[194]

As Kennedy and Khrushchev watched the crisis spiral out of their control, they saw the need to communicate and cooperate to fight a shared risk: human error. Both leaders never intended to start a nuclear war or hoped to survive one. In one of the most profound empathic breakthroughs of modern history, they found common ground in their struggle to control all their strategic and tactical nuclear weapons and prevent an accidental atomic holocaust.

The Cuban missile crisis marked a major turning point in the Cold War. For some onlookers, the thirteen days in October 1962 proved the value of massive retaliation as a national

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[192] Theodore Sorensen. *Kennedy*. (Harper & Row: New York, 1965). Pg. 513.
[193] Robert F. Kennedy. Pg. 84.
[194] "Letter from Jacqueline Kennedy to Chairman Khrushchev." December 1, 1963. Ed. Thomas Fench. *The Kennedy-Khrushchev Letters.* (New Century Books: The Woodlands, 2001). Pg. 566.

security strategy for dissuading a Soviet attack. Staring down the barrel of America's nuclear deterrent, Khrushchev blinked. As the ideological struggle between the free world and the communist block stormed onward, military strategists and international relations scholars rationalized the crisis, coming up with complex explanations of the President's decisions to fit their game theories and deterrence models.

However, for Kennedy, Khrushchev and other key decision makers, the crisis only proved the danger of military escalation in the atomic age. The possibility of a total nuclear war grew more frightening than the probability of an intentional attack. As the leaders worked to minimize the risk of human error sparking World War III, they found themselves on the same side. Both countries would have to live in a post-nuclear world, and neither wanted to. Their aversion to such a terrifying future was more powerful than their aversion to each other.

The Cuban missile crisis sparked a new security logic based on communication and cooperation in the face of collective risk. At the Eighteen Nation Disarmament Committee in June 1963, the two superpowers set up a direct hot line between the White House and the Kremlin. Kennedy and Khrushchev agreed that the twelve hours it took to receive and decode a message had stalled a fast resolution to the crisis and heightened the risk of nuclear conflagration. A month later, both countries signed the Limited Test Ban Treaty (LTBT), which halted all test detonations except those performed underground. The LTBT reflected a mutual desire to end the arms race and de-escalate. The crisis in Cuba had proved that keeping the US and Soviet military machines ready for immediate combat didn't decrease the threat of attack but increased the risk of inadvertent war. The more pieces in motion, the more likely one would break down. Considering the stakes, Kennedy and Khrushchev recognized the need to cooperate in order to minimize the chance of that happening.

The US Senate ratified the LTBT on September 24, 1963. It went into effect in early October. The treaty's quick implementation reflected acute concern from both nations of the long-term environmental effects of nuclear fallout. The environmental effects of nuclear weapons testing had become a prominent issue of debate, and as Kennedy struggled back from the brink of direct conflict, it was clear that a nuclear war would do untold damage to the biosphere. America's nuclear fears were wrapped a rising ecological consciousness that recognized its ability to systemically destroy its natural support system. A month before U-2 photos found the missiles in Cuba, Rachel Carson came out with her powerful book *Silent Spring*, launching the modern environmental movement. As citizens, scientists and decision-makers wondered how the earth would respond to a nuclear World War III, they primed themselves for America's next great risk: ozone depletion.

Science of the Stratosphere

> "As with all too many last examples, we have failed to conduct a broad and vigorous program of basic research so that we just don't have all the answers at hand when technological change suddenly calls for assessing hazards."[195]

- Open understanding

The US perception of ozone depletion was conditioned by facts and fears carried over from the atomic age. Before the ozone layer became an issue of concern, nuclear weapons testing made up the brunt of US investment in atmospheric science. Sampling radioactive fallout from nuclear detonations allowed the military to estimate combat damage and monitor the Soviet nuclear project.[196] A clear understanding of how missiles left and reentered the edges of earth's atmosphere was imperative for designing new missiles and upgrading the US arsenal. As physicists, chemists and engineers worked to improve America's deterrent, they developed the tools civilian scientists needed to study the stratosphere. However, government-sponsored research focused on improving the military utility of the weapons and largely ignored developing an accurate picture of their long-term atmospheric effects. Serious investment in understanding the ozone layer – its composition, dynamics and significance – only began after civilian experts proved it was worth looking into.

While the science surrounding nuclear weapons began as a national security secret, research on atmospheric ozone evolved as a public, civil endeavor. After Christian Schonbein first noticed the chemical compound ozone (O_3) in 1839, the detection of "an easily measured, chemically reactive substance in air sparked wide interest… within a few years ozone was being

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[195] James McDonald. "Civil Supersonic Aircraft Development. Continuing Appropriations." *Hearing before the House Subcommittee on DOT Appropriations* (Washington D.C., March 1, 1971).
[196] Seth Cagin and Philip Dray. *Between Earth and Sky: How CFCs Changed Our World and Endangered the Ozone Layer.* (Pantheon: New York, 1993). Pg. 169.

measured in hundreds of locations."[197] In 1880, William Hartley found that ozone molecules absorbed high frequency UV radiation (200-300 nm). Since studies showed that the light reaching the earth from space cut off at similar wavelengths, Harley posited that ozone blocked those wavelengths of light somewhere in the atmosphere. Around the turn of the century, high-altitude weather balloons confirmed that a warmer region of the atmosphere lay above the colder, denser troposphere. This new atmospheric region, named the stratosphere, was warmed as ozone absorbed high frequency UV rays.

In 1913, Charles Fabry and Henri Buisson began measuring the altitude and thickness of the ozone layer.[198] Building on their work, G. M. Dobson developed a practical instrument to measure total ozone in a column of air from surface to space. Dobson and his team began setting up stations around the world to monitor global ozone patterns.[199] In 1930, Sidney Chapman proposed a series of basic photochemical reactions that explained how ozone absorbed high intensity UV rays, broke apart, and reformed in a dynamic screen across the stratosphere.[200] His theory grounded future meteorological research on stratospheric ozone and established a more accurate picture of how it accumulated and circulated around the earth.[201]

It also led early atmospheric scientists to recognize that the ozone layer was essential for human survival. Quoted in an October 30, 1933 *NYT* article, Dr. Charles Abbott of the Smithsonian Institution explained how the ozone layer shielded all life on earth from deadly

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[197] Edward Parson. *Protecting the Ozone Layer: Science and Strategy*. (Oxford University Press: New York, 2003). Pg. 14.
[198] Joseph F. Mulligan. "Who were Fabry and Pérot." *American Journal of Physics* 66 (9) (September 1998): 797-802.
[199] They found that ozone concentrations oscillated with local weather conditions and seasonal changes, but overall, higher latitudes of the earth had more ozone than the equator.
[200] I will not explain the chemical reactions in detail, as they are outside the scope of my project.
[201] Further research done by Brewer and Dobson backed the theory that ozone formed in the stratosphere above the tropics and circulated to the higher latitudes. See A. W. Brewer. "Evidence for a World Circulation Provided by the Measurements of Helium and Water Vapour Distributions in the Stratosphere." *Quarterly Journal of the Royal Meteorological Society* 75 (1949): 351-63; G. M. Dobson. "Origin and Distribution of Polyatomic Molecules in Atmosphere." *Proceedings of the Royal Society* A236: 187-93.

shortwave radiation, and "were this trifling quantity of atmospheric ozone removed, we should all perish."[202] A year later, Dorothy Fisk wrote in her book, *Exploring the Upper Atmosphere*: "The effect of unlimited solar radiation would be fatal, and this layer of ozone, no thicker than a wafer biscuit, is all that stands between us and speedy death."[203] Anyone who knew UV radiation could be lethal considered stratospheric ozone a prerequisite for human wellbeing. From the ozone layer's inception as a common concept, anything that endangered its equilibrium was clearly understood as a threat to *homo sapien* existence.

Academics and enthusiasts caught their first hint of scientific scandal in the early 1960s. Dobson's global network of ozone monitors had compiled more than thirty years of data, giving atmospheric scientists a relatively accurate idea of how ozone was dispersed around the world, and how concentrations oscillated with seasons and weather patterns. As the picture sharpened, it began to undermine early theoretical explanations of ozone photochemistry. High-altitude U-2 flights found three times less ozone than Chapman's original model could account for.[204] By 1965, a serious problem existed "in reconciling the observed O_3 distribution in the atmosphere with that derived from chemical theory."[205] The reactions chemists had proposed to describe how ozone molecules continuously form and break apart had predicted too much stratospheric ozone, meaning that other sinks – processes that absorb or eliminate stratospheric ozone – had to be present to explain why it fluctuated at a lower equilibrium.[206] Scientists suspected that trace gasses might explain the discrepancy, as they could scavenge ozone in a catalytic cycle: a chemical sequence in which one molecule destroys another without being destroyed itself.[207]

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[202] Cited in Seth Cagin and Philip Dray Pg. 136.
[203] Ibid.
[204] Seth Cagin and Philip Dray. Pg. 157.
[205] B. G. Hunt. "The Need for a Modified Photochemical Theory of the Ozonosphere." *Journal of the Atmospheric Sciences* Vol. 23 (January, 1966): 88-95.
[206] Edward Parson. Pg. 18.
[207] Seth Cagin and Philip Dray. Pg. 157.

Almost invisible amounts of certain compounds, then, could eat up large amounts of ozone. As scientists explored and identified these chemical sinks, they realized that human activities could amplify each one, effectively altering the balance of ozone dispersed across the atmosphere.

The first proposed sink was water vapor.[208] In the early 1960s, researchers noticed that the HOx cycle – the chemical process in which HO_2 splits into H, O, HO, and/or O_2 – was linked to the cycle of stratospheric ozone formation and destruction.[209] Water molecules collided with single oxygen atoms in the stratosphere, creating compounds that in turn break up ozone molecules, form water and start the cycle over again. The rate could still only be estimated, but it roughly aligned with the observed quantity of ozone, meaning that the HOx cycle could be the missing sink. Researching how ICBMs reentered earth's atmosphere, John Hampson quickly noted that if these rates proved true, any additional water vapor injected into the stratosphere – from rocket launches, atmospheric nuclear tests, or stratospheric aviation – could significantly deplete the ozone layer.[210]

- Defining progress

The ozone layer had long been considered a vital organ of earth's life support system, and evidence compiled throughout the 1960s confirmed that it was irreplaceable. In 1965, two scientists published an article in the *Journal of Atmospheric Sciences* entitled "On the Origin and Rise of Oxygen Concentration in the Earth's Atmosphere." They argued that hundreds of millions of years ago, primitive cellular organisms in shallow pools photosynthesized enough

[208] A theoretical reaction for ozone destruction by hydrogen radicals had been proposed in 1950, but atmospheric scientists thought that HO_2 only split apart above the stratosphere, where UV rays carried enough energy to break its molecular bonds. See: David R. Bates and Marcel Nicolet. "The Photochemistry of Atmospheric Water Vapor." *Journal of Geophysical Research* Vol. 55, No. 3 (September 1950): 301-326.
[209] W. D. McGrath, and R. G. W. Norrish. "Studies of the Reactions of Excited Oxygen Atoms and Molecules Produced in the Flash Photolysis of Ozone." *Proceedings of the Royal Society* 254 (1278) (February 23, 1960): 317-326.
[210] Edward Parson. Pg. 24.

oxygen to overcome the rate of photodissociation (destruction by UV rays) and slowly build an oxygen atmosphere. When oxygen concentration reached a "critical first level," ocean surfaces were "sufficiently shadowed [from lethal UV radiation] to permit widespread extension of life to the entire hydrosphere."[211] At a "second critical level," organic life could evolve onto land.[212] Only in the late Silurian age, 420 million years ago, was there "sufficient oxygen in the atmosphere to support the total O_3 levels to shadow the lethal UV from the surface," kick starting organic evolution and selecting for species with more advanced respiratory and circulatory systems, eventually including humans.[213] The ozone layer was therefore a prerequisite for the existence and evolution of life on earth, and any threat to its atmospheric equilibrium was a threat to all species, whether mammal, reptile or bacteria. It would take decades to understand how stratospheric ozone concentrations fluctuated and circulated around earth, but the fact that the ozone layer underwrote human survival was proven and accepted early on. The scientific consensus on ozone's importance structured how government, industry, and civil society responded to the risk of its destruction.

This consensus solidified just as the US SST program came under serious public scrutiny.[214] Supersonic aviation began as an Air Force exercise in 1956, to concerns of noise and damage.[215] Behind every Mach I flight trailed a shock wave that startled people, cracked building foundations and shattered windows on the ground below.[216] The French and the British launched the first mission to design and construct a commercial supersonic jet in 1962. The Concorde, as the aircraft was named, expected to revolutionize commercial aviation by flying higher and faster

[211] L.V. Berkner and L. C. Marshall. "On the Origin and Rise of Oxygen Concentration in the Earth's Atmosphere." *Journal of Atmospheric Sciences* Vol. 22, No. 3 (May 1965): 225-261.
[212] Ibid.
[213] Ibid.
[214] For a more extensive history of the SST controversy, see: Mel Horwitch. *Clipped Wings: The American SST Conflict*. (MIT Press: Cambridge, 1982).
[215] Seth Cagin and Philip Dray. Pg. 150.
[216] Ibid.

than ever before. Enthusiasts envisioned a world connected by high-speed stratospheric flight, a future in which a New York businessman could fly to Paris for dinner and be back in time for dessert.[217] Worried the US aviation industry would get leapfrogged by European innovation, President Kennedy approved funding for an American SST program in 1963. His successors Johnson and Nixon both continued to publicly support the program as a matter of national pride, despite growing complaints of noise pollution and high funding costs.

In 1966, the National Academy of Sciences (NAS) asked James McDonald from the University of Arizona to investigate whether water vapor emitted from SST exhaust could severely alter large-scale climatic patterns. Leaving the jet engines, the vapor froze in the stratosphere and formed large contrails, and the NAS worried that the clouds would block the sun and potentially change the earth's temperature. Leaving the theoretical link between HOx and ozone depletion aside, McDonald concluded that the water vapor released in SST emissions would not be sufficient to affect climate present a serious environmental problem. However, as the theoretical reaction between hydrogen oxides and ozone molecules gained credibility, the effect of SST emissions on stratospheric ozone concentration became the subject of vigorous scientific debate. In an effort to clear up uncertainty, the NAS commissioned McDonald to reexamine the effects of SSTs on the atmosphere, widening the investigation's scope to include the consequences of water vapor emissions for stratospheric ozone levels and the larger implications for public policy and human wellbeing.

The entire SST debate was steeped in a new culture of environmental consciousness, marked by strong skepticism towards blind technological progress and a firm faith in the power of scientific inquiry to understand the natural world. John Gibson's summer 1966 article in

[217] Auguste Piccard. "Ballooning in the Stratosphere: Two Balloon Ascents to Ten-Mile Altitudes Presage New Mode of Aerial Travel." *National Geographic* 63 3 (March 1933).

Harper's Magazine, entitled "The Case Against the Supersonic Transport," marked a turning point in public opinion by identifying the SST as the latest example of technological excess in a trend that stretched "far back into American history."[218] Citizens moved away from the technocratic sensationalism of the 1950s and towards a more cautious, pragmatic ethos that understood America's capacity to innovate into extinction. *The Washington Post* observed, "to be against the SST is not to be against technological advance but to question about its pace and direction."[219]

As evidence grew suggesting a commercial SST industry would generate major noise pollution, the Sierra Club, the National Wildlife Federation, the Wilderness Society and other concerned citizen's groups banded together to put pressure on Washington. In an effort to educate citizens on the ecological dangers of SSTs, William Schurcliff published the *SST and Sonic Boom Handbook*, which joined *The Population Bomb*, *The Frail Ocean*, and *Operating Manual for Spaceship Earth* in a "burst of pop techno/environmental literature flooding college campuses."[220] Schurcliff's book came out just in time for the first official Earth Day. Congress would have to vote on continuing to fund Boeing's two SST prototype projects, and growing opposition had many representatives reconsidering their support. Those who already found SSTs noisy or expensive were eager to entertain the idea that they caused profound environmental damage. Ozone loss was the last leak found in a sinking ship.

- Incremental apocalypse

The SST debate underwrote the stratospheric research that ultimately proved stratospheric ozone's significance for life on earth and its vulnerability to human impact.

[218] John E. Gibson. "The Case Against the Supersonic Transport." *Harper's Magazine* (July 1966).
[219] "The Lift of a Driving SST." *The Washington Post*. March 23, 1971.
[220] Ibid. Pg. 156.

McDonald's testimony to the House Appropriations Subcommittee for Transportation on March 1, 1971 connected the dots between SSTs, ozone loss and a specific, immediate hazard to US citizens. Trying to compress decades of scientific investigation and debate into one statement, McDonald talked fast, and the Representatives had a hard time keeping up. Many were skeptical of his credibility, especially considering he had testified earlier in support of funding a federal investigation into UFO sightings.[221] With little understanding of atmospheric physics or chemistry, a few dismissed his condensed and rapid synopsis of the ozone layer as nonsense. However, McDonald was well respected within the scientific community, and others knew he wouldn't testify without substantial evidence to back his claim. Responding to one Representative's attacks, McDonald exclaimed, this "is not nutty, it is not ecological extremism. It is physics and chemistry, photochemistry, cell biochemistry, atmospheric physics."[222]

After months of reviewing the latest research on current stratospheric ozone levels, the HOx cycle and the biological effects UV radiation, McDonald concluded that the greatest SST problem was not sonic booms but skin cancer. Using Leovy and Harrison's earlier studies to assign a theoretical rate to the HOx cycle, he estimated that the proposed SST fleets could deplete as much as five percent of the ozone layer. Being conservative, even a loss of one percent would cause 5,000 to 10,000 more cases of skin cancer per year, and that was in the US alone. For every additional percent of ozone lost, total skin cancer cases would increase by roughly six percent across northern latitudes of the earth, where the ozone layer was thinnest.[223] When Senator Proxmire asked Gio Gori of the National Cancer Institute to evaluate McDonald's medical assessment a week later, Gori reported that the health hazard created by ozone depletion was grossly underestimated. McDonald's projected increase in human exposure to high-

[221] James McDonald. "Civil Supersonic Aircraft Development. Continuing Appropriations."
[222] Ibid.
[223] Ibid.

frequency UV radiation would cause 100,000 more US cases of skin cancer each year, and skin cancer would be just one of the myriad adverse health effects.[224]

While the numbers were alarming, it was the clear causal connection between SST emissions, ozone depletion, increased UV radiation, and cancer that made McDonald's testimony so powerful. After thirty years of biomedical research, by 1971, the positive link between prolonged exposure to high-intensity UV radiation and various types of skin cancer was "beyond dispute," and the ozone layer's role in shielding life on earth's surface from the same type of radiation was equally unquestionable.[225] As he explained, "The ozone in the stratosphere, as portrayed in that diagram, is the only difference between being exposed to all of the solar ultraviolet, which would do us in in a very short time, and being protected."[226] Obviously distressed by his findings, McDonald concluded:

> The purely biological and evolutionary evidence that we, as well as all other life forms, have evolved in ways leaving us only marginally protected from highly adverse effects of ultraviolet radiation is essentially incontrovertible… We just can't stand that ultraviolet, and the whole history of evolution, it is becoming clearer and clearer, has been a battle with ultraviolet. We have always just barely won.[227]

Any depletion of stratospheric ozone would not only threaten human health, but also damage all the plants and animals upon which US citizens depended for subsistence. When Representative Sydney Yates asked if ozone depletion would harm "crops and things of that sort," McDonald acknowledged: "Plants are susceptible to ozone damage. That is well tested in the literature… What about animals? It turns out that in Arizona and Texas spotted Hereford is cancer sensitive."[228] Reflecting on the full implications of McDonald's conclusions for government policy, Yates summarized, "What you are saying is, let's go slow before we

[224] Seth Cagin and Philip Dray Pg. 164.
[225] James McDonald.
[226] Ibid.
[227] Ibid.
[228] Ibid.

authorize the production of the plane? McDonald replied, "I think so, because of the very point I stressed… that it is awfully easy to get beyond the point of no return. That is my feeling, and that is the reason I am concerned."[229] While atmospheric scientists had long known the ozone layer underwrote the evolution of life on earth, McDonald's testimony proved how its depletion directly damaged human health and wellbeing. He identified the immediate threat by showing how SST exhaust catalytically destroyed ozone molecules in the stratosphere, but more importantly, McDonald showed how the risk of ozone molecules being destroyed by anything affected human survival. While ozone loss was incremental – flying two SST prototypes "wouldn't be a hazard" – it represented an existential risk because an atmosphere without an ozone layer would leave earth's surface fully exposed to lethal UV radiation. The question was never whether humans could survive in such a hostile environment – they couldn't – but how fast humans could create it.

Standing before Congress, McDonald clearly articulated the global scale of the ozone risk, placing it in the same existential category as atomic innovation. Emphasizing the need for international cooperation to manage such hazards, he asserted:

> We face a problem comparable to that which has been a difficulty for more than a decade, the international aspects of bomb tests, radioactivity as a global health problem, and we have with difficulty and slowness managed to begin to take a somewhat international look at that problem. Technology in general is getting to be an international problem and this is only one more example of many such difficulties coming up.[230]

McDonald could see the historical trend. Human ingenuity had reached the point of threatening global security, and without a strong international movement to regulate it, one country's blunder could mean transnational chaos. He stressed how the environmental reality required a new logic of foreign policy that recognized humanity's collective fragility:

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[229] Ibid.
[230] Ibid.

> The real question at stake is thus the question of whether it is acceptable to any and all nations to have operating in the stratosphere a heavy air transport technology which might impose any globally unacceptable environmental burdens affecting any or all national interests. The inherently international characteristic of the problem, when properly appreciated, requires that the United States or Russia view the Concorde program just as critically as the British or Russians must view the American program, et cetera.[231]

McDonald's testimony introduced the ozone layer to US policymakers and citizen's as a vital ecological system that was vulnerable to human impact anywhere and supported human societies everywhere. These defining characteristics drove American's belief that ozone depletion was an existential risk. As a critical global commons, nations would have to communicate and cooperate to ensure its protection. One Senator observed, "We cannot afford to let one nation decide for all mankind."[232] Citizens and policymakers began to reject US ventures that contributed to the problem and call for an international solution.

Watching McDonald give his statement, Joseph Hirschfelder was alarmed. An alumni of the Manhattan Project and a veteran of the Los Alamos Atomic Bomb Laboratory, Hirschfelder was one of the premier theoretical chemists of his time, and could see the logic connecting SST emissions, catalytic ozone-destroying reactions, amplified UV exposure, and human suffering. He was also a member of the Department of Commerce's Technical Advisory Committee. Taking McDonald's data and deductions seriously, he invited the top atmospheric scientists and public-health officials to an emergency meeting in Boulder. While many of the experts criticized McDonald's findings, none were more aggressive than Arnold Goldburg, the chief scientist of Boeing's SST division. Though he supported funding a vigorous research effort to clear up uncertainty, Goldburg essentially cross-examined McDonald, attacking every one of his conclusions. As UC Berkeley's Harold Johnston recalled "I have never seen any person at any

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[231] Ibid.
[232] A Threat to Life." *The New York Times*. June 13, 1971.

scientific meeting so abused as McDonald was during the course of presenting his paper."[233] Harold Johnston was one of the world's experts in ozone chemistry and distribution, and arrived in Boulder concerned by McDonald's research. Although he followed McDonald's logic that SST emissions could dangerously deplete ozone in the stratosphere, he deviated over how. Johnston suspected that trace amounts of nitrogen oxide in SST exhaust could destroy stratospheric ozone in a catalytic cycle that would be much more damaging than water vapor.[234]

As scientists in Boulder discussed the chemical mechanisms that could destroy ozone molecules in the stratosphere, Congressmen in Washington voted on the SSTs future. On March 17, 1971, the House effectively killed the US-Boeing SST program by refusing to fund another year of research and development. Based primarily on concerns of cost and noise, the SST decision represented a rejection of technology for technology's sake and a growing awareness that "progress" could infringe on wellbeing. President Nixon lamented that the US had missed an opportunity to lead the world into the next stratospheric frontier, but as *Newsweek* remarked: "In the wised up seventies, that sort of appeal to national pride may be losing its old magic. [There is] a growing feeling that America needs to rethink its national priorities and that the technological adventures it has funded unquestionably in the past may be one good place to begin."[235]

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[233] Lydia Dotto and Harold Schiff 47.
[234] Harold Johnston was a student at Cal Tech in the late 1940s, and had helped Professor Haagen-Smit prove that smog around London, Los Angeles and other urban areas was mostly ozone molecules, which formed as the nitrogen oxide from car and factory emissions collided with UV radiation and oxygen in the lower troposphere. His research helped prove smog to be a serious health hazard and represented a scientific step forward in the environmental movement against air pollution. Under Haagen-Smit, Johnston had worked and reworked equations showing how nitric oxide could photochemically react with ozone. See: Seth Cagin and Philip Dray Pg. 165.
[235] "The House Falls in on the SST." *Newsweek*. March 29, 1971. Found in: Seth Cagin and Philip Dray Pg. 167.

Connecting the Dots

"These scientific hypotheses underscore the simple truth that man is not the easy master of the universe. There is much concerning the stratosphere and the life processes on this planet about which man is still ignorant. The ozone destruction theory may prove incorrect, but it would be wildly reckless to gamble on the unknown."[236]

- Momentum

Although the SSTs effect on stratospheric ozone concentrations had little effect on Congress's decision, the debate introduced the ozone layer as a common concept, and publicly established its crucial role in protecting life on earth. Returning to Berkeley from the Boulder conference, Johnston was convinced it was possible that overlooking the SSTs effect on nitrogen oxide concentrations in the stratosphere would lead the world "right into an absolute disaster."[237] Cleaning up his research, he sent his calculations of extreme ozone loss from SSTs and the NOx cycle to *Science* for review. His peers rejected the first draft partially because he didn't cite a key article that backed his theory, but mostly because of its sensationalism.[238] Calculating that an SST fleet could destroy three to twenty-three percent of ozone globally and cut it in half over the Atlantic flight corridor, he had included a "foolish statement" on the effect of ultraviolet radiation on snow blindness and the potentially catastrophic implications of large ozone losses.[239] Johnston wrote that with such serious depletion,

> …all animals of the world (except, of course, those that wore protective goggles) would be blinded if they ventured out during the daytime… In view of the eye-destroying, deadly nature of the radiation shield from the surface of the earth by ozone, the prospect

[236] "A Threat to Life."
[237] Lydia Dotto and Harold Schiff. Pg. 59.
[238] In 1970, Dutch meteorologist Paul Crutzen had documented how nitrogen oxide released from decomposing organic material on earth's surface rose into the stratosphere and proposed that a natural NOx cycle could scavenge ozone. See: Paul J. Crutzen. "The influence of nitrogen oxides on the atmosphere ozone content." *Quarterly Journal of the Royal Meteorological Society* 96 (1970): 320-5.
[239] Harold S. Johnston. "Atmospheric Ozone." *Annual Review of Physical Chemistry* 43 (October 1992): 1-32. In this article, Johnston gives a thorough recount of his involvement in the ozone debate. See also: Harold S. Johnston. "Reduction of Stratospheric Ozone by Nitrogen Oxide Catalysts from Supersonic Transport Exhaust." *Science* 173, (August 6, 1971): 517-22.

> of the destruction or the major reduction of the ozone layer should be regarded as a matter of utmost worldwide concern.[240]

Johnston removed the statement before publication, but a draft leaked to the press and quickly caught the nation's attention. On May 30, the renowned science editor for the *NYT* Walter Sullivan printed a clear exposition of Johnston's research, placing the ozone layer directly in front of the public in terms they could understand. He concluded that its essential role in protecting the biosphere, and its vulnerability to nitrogen oxide from SSTs, was "a reminder that some of the factors that make the world habitable for all higher forms of life are fragile. Their care and sustenance must be mastered before we endanger their survival – and our own."[241] Sullivan and other journalists both explained and influenced the ozone debate as it grew to prominence in the late 1970s. Their reporting helped establish a baseline of legitimate knowledge that shaped public perception of the ozone layer and the risk of its depletion.

The tumultuous process of developing a scientific consensus on the chemical mechanisms of ozone destruction had many convinced that ambiguity was too high to beget action. Scientists from industry and academia argued over the details, and there were many exploitable unknowns for those that would stand to lose under a state-regulated stratosphere. But from the outset, the experts agreed on the implications: any threat to the ozone layer, whether from SSTs or anything else, was a threat to human survival.

While ozone loss was incremental – it wouldn't just disappear all at once – the risk of destroying it completely was existential in scale and intensity. Earth without the ozone layer would be uninhabitable. With the help of Sullivan and other early "knowledge brokers," this information circulated as fact, and was crucial for building enough concern to influence

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[240] Quoted in Lydia Dotto and Harold Schiff. Pg. 60.
[241] Walter Sullivan. "Sorry, but There's Still More to Say on The SST: Ozone." *The New York Times*. May 30, 1971.

policy.[242] It was also advertised as urgent. Covering Johnston's findings, some journalists misinterpreted his data and reported that "stratospheric ozone will be cut in half in six months."[243] Caught in a wave of ecological awareness sweeping the nation, the ozone layer and its function in the biosphere quickly became a household conversation. In 1972, NASA took and released the first clear image of earth's illuminated surface, providing Americans with a powerful image of how small, isolated, and irreplaceable their blue marble truly was. As the public grappled with the stakes, they opposed any activity that damaged their stratospheric shield. However, like nuclear weapons, the decision to develop an SST industry was made in the halls of the federal government, and citizens had little direct impact on the rate of ozone layer damage. With CFCs and spray cans, that would change.

The SST debate, and the attention it brought to the ozone layer, marked the beginning of an ambitions investigation into human impact on the stratosphere and a broader federal investment in climate science. Measured a few months after McDonald's testimony, the rate of the original HOx reaction proved much too slow for water vapor to be the primary ozone sink. But by then Johnston's proposed NOx cycle had replaced it as a more likely and more dangerous ozone-scavenger, and the Department of Transportation immediately backed a three-year project to assess the stratospheric pollution from SSTs. The Climate Impacts Assessment Program (CIAP) involved over a thousand scientists from ten different countries. Along with research initiatives sponsored by the NAS, United Kingdom and France, CIAP helped build the foundation for an integrated assessment of earth's atmosphere, and represented one of the "first

[242] Karen T. Litfin defines knowledge brokers as the "intermediaries between the original researchers, or the producers of knowledge, and the policymakers who consume that knowledge but lack the time and training necessary to absorb the original research." *Ozone Discourses: Science and Politics in Global Environmental Cooperation.* (Columbia University Press: New York, 1994).
[243] Harold S. Johnston. "Atmospheric Ozone."

efforts to assess the potential impact of a technology note yet in widespread use."[244] The SST threat faded from public consciousness as industry and government gave up on the dream of commercial stratospheric flight. But the models and measurements needed to evaluate the SST's environmental consequences grounded scientific understanding of America's next and biggest ozone threat, aerosols.

- The miracle compound

By the time the ozone layer became a common concern, chlorofluorocarbons (CFCs) were a primary element of US industrial production and manufacturing. They provided the chemical foundation for the modern American lifestyle, and were tied in some way to almost every profitable industry in the country. As Kevin Fay of the CFC Alliance reflected in 1988, "The way life has evolved in this country in the past 30 years, CFCs have been at every major turn."[245]

In 1928, General Motors commissioned a small team of scientists from their Frigidaire division to synthesize a compound that could supplant the principle coolants of the day, dangerously toxic or inflammable chemicals like ammonia, methyl chloride, and sulfur dioxide.[246] Looking for a safe and effective substitute, GM chemist Thomas Midgley identified dichlorodifluoromethane (CFC-12), an odorless, colorless compound that was cheap to produce and carried no visible health impacts.[247] At the annual American Chemical Society conference in 1930, he inhaled the vapors from a beaker of liquid CFC-12 and blew out a candle, proving it

[244] Naomi Oreskes and Erik Conway. *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming.* (New York, NY, Bloomsbury Press, 2010). Pg. 110.

[245] Quoted in Michael Weisskopf.

[246] For more information on the invention and development of CFCs, see: L. E. Manzer. "The CFC-Ozone Issue: Progress and Development of Alternatives to CFCs." *Science*, Vol. 249, No. 4964 (Jul. 6, 1990): 31-35.

[247] CFCs are derived by replacing the hydrogen atoms of simple hydrocarbons with fluorine or chlorine.

was neither toxic nor flammable.[248] Midgley had been a key player in the development of leaded (ethyl) gasoline, and his colleagues praised his ingenuity. His legacy of hazardous innovations, however, would have future historians calling him the single most ecologically destructive organism in world history.[249]

The invention of CFCs revolutionized the cooling industry. In a joint venture with DuPont, General Motors began designing commercial refrigerators with CFC-12, and put the first one on the shelves in 1933. Without the danger of toxic leakage, CFC-based freezers and refrigerators quickly became standard household appliances, replacing most ammonia- and sulfur dioxide-based refrigerators by 1945.[250] Advertised as the "miracle" substance Freon, this family of chemicals – CFC-11, -113, -114, along with HCFC-22 and others – paved the way for a new generation of cooling technology. Aside from expanding the domestic refrigeration market, CFCs spurred innovation in air-conditioning and industrial cooling systems. By the 1950s, cumulative production of CFC-11 and -12 had skyrocketed from one to over seventy-five million pounds.[251] CFC-based refrigeration could soon be found almost everywhere, from schools, hospitals, offices and shopping malls to the cars parked outside.[252] In this sense, they "redefined comfort and shaped social habits:" CFCs streamlined the US food distribution network, led the urbanization and development of the Sun Belt, and put "the nation on wheels for summer vacations."[253]

The same stability and versatility that made CFCs so popular as a coolant also made them the go-to compound for a variety of non-refrigeration applications. During World War II,

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[248] Michael Weisskopf. "CFCs: Rise and Fall of Chemical 'Miracle'; Chlorofluorocarbons vs. Ozone." *The Washington Post* (April 10, 1988).
[249] See J. R. McNeill. *Something New Under the Sun: An Environmental History of the Twentieth-Century World.* (W. W. Norton: New York, 2001).
[250] Karen T. Litfin. Pg. 59.
[251] Ibid.
[252] Seth Cagin and Philip Dray. Pg. 69.
[253] Michael Weisskopf.

military investment in plastics research accelerated as the government searched for lightweight, durable materials for building equipment and outfitting troops. The Dow Chemical Company first used CFC-12 to blow polystyrene plastic into a rigid foam that was lightweight and durable, creating the loose prototype for what would become Teflon, Styrofoam and a host of other synthetic materials.[254] CFC-blown foams soon became the principal raw material for furniture, car and mattress cushioning. With double the thermal insulating capacity of fiberglass, they replaced it as the primary insulator for buildings and appliances.[255] As the aerospace, electronics and computers industries grew, CFCs were picked out as ideal cleaning solvents for microchips and other delicate synthetic parts.

The largest commercial application of CFCs was as a propellant in aerosol spray cans. Like plastics, aerosol cans were developed and manufactured at large scale during World War II. These "bug bombs" used CFC-12 to deliver sprayable insecticides to US troops suffering from malaria-carrying mosquitoes in the Pacific theater. [256] Commercialized after the war, aerosol cans rapidly became the standard packaging for a wide range of deodorants, hairsprays, cleaning products, paints and insecticides. Aerosol spray cans were one of America's fastest growing industries: between 1950 and 1960, annual sales increased one hundred fold, from five million to five hundred million cans.[257] By the 1970s, sales had risen another 500 percent, and the industry accounted for half of all CFCs produced each year. Once Americans connected the dots between CFC emissions and ozone depletion, they quickly put aerosol cans on trial as the deadliest and most obvious perpetrator.

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[254] Edward Parson. Pg. 21.
[255] Ibid. Pg. 22.
[256] Edward Parson. Pg. 21.
[257] Lydia Dotto and Harold Schiff. Pg. 146.

The research that ultimately implicated all CFCs in the destruction of atmospheric ozone coalesced as government, industry, and academia mobilized to understand how human technologies affected the stratosphere. In the late 1960s, James Lovelock invented an instrument to measure trace gases in the atmosphere at concentrations as small as 1 part per trillion. Reasoning that stability of CFCs as compounds would make them an excellent tracer of large-scale atmospheric patterns, he began measuring CFC-11 concentrations to map air currents crossing Britain from Europe and the Atlantic. He published his results in 1971, and at conference that summer his calculation of total atmospheric CFC-11 aligned with Ray McCarthy's estimate of all CFC-11 ever produced, implying that CFC-11 remained in the atmosphere for decades.

Ray McCarthy was DuPont's Freon Products Lab Director, and immediately began investigating the environmental fate of CFCs. While Lovelock believed CFCs were "not in any sense a hazard" to the environment, McCarthy worried they could contribute to smog formation in the troposphere or cause other adverse health problems.[258] In the fall of 1972, Du Pont organized a conference for CFC producers in Andover, where they agreed to establish a joint research program under the Chemical Manufacturer's Association (CMA, then called the Manufacturing Chemist's Association) to better understand the atmospheric presence of CFCs.[259] The Flourocarbon Program Panel, as it was called, dispensed $3 to $5 million in university contracts, funding a series of discrete projects to measure how fast CFCs absorbed different wavelengths of light, where they showed up in the atmosphere, and how they might pollute it.[260]

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[258] James E. Lovelock. "Atmospheric Fluorine Compounds as Indicators of Air Movements." *Nature* 230 (April 9, 1971): 379. See also: James E. Lovelock and others. "Halogenated Hydrocarbons In and Over the Atlantic." *Nature* 241 (1973): 194-6.
[259] Edward Parson. Pg. 23.
[260] Lydia Dotto and Harold Schiff. Pg. 149.

As the picture of how CFCs circulated through the biosphere came into focus, two University of Michigan scientists received a contract to examine the environmental impact of NASA's newest shuttle.[261] Ralph Cicerone and Richard Stolarski reported that the shuttle's solid-propellant rocket boosters released chlorine compounds directly into the stratosphere, where they destroyed ozone in a "potentially much faster [ClOx] chain" than the HOx and NOx reactions.[262] But Cicerone and Stolarski were relatively new at stratospheric chemistry, and NASA pressed for further study before coming forward with any formal publication. When Cicerone and Stolarski released their official report in June 1973, the NASA program office in Houston worried about possible backlash against the shuttle and initially tried to bury the conclusions.[263] The scientists agreed to publish their findings without directly implicating the NASA shuttle. At a conference in Kyoto in September, they presented a paper showing how chlorine emitted from volcanoes could scavenge ozone in the stratosphere.

Although the chlorine-ozone reaction was in itself a significant scientific discovery, the only human source of stratospheric chlorine was far too small to represent any serious ozone threat. NASA scheduled a workshop to address the problem, and though they concluded that the shuttle constituted a "small but significant" addition to natural sources of chlorine in the stratosphere, even with fifty flights a year, the shuttle would only cut the ozone layer by about .3 percent.[264] Without a larger source of stratospheric chlorine, the discovery had few implications for policy, and the shuttle story barely reached the public.

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[261] The National Environmental Policy Act, passed in 1969, set up the federal guidelines for systematically assessing how proposed government programs would affect the environment. The Act required NASA to prepare an Environmental Impact Statement for its newest space shuttle, and in the summer of 1972, Ralph Cicerone and Richard Stolarski were commissioned to review it.

[262] Ralph Cicerone and others. "Assessment of Possible Environmental Effects of Space Shuttle Operations." *NASA CR-129003* (June 3, 1973).

[263] Naomi Oreskes and Erik Conway. Pg. 111.

[264] Lydia Dotto and Harold Schiff. Pg. 134; Seth Cagin and Philip Dray Pg. 136.

Sherwood Rowland and Mario Molina from the University of California Irvine put the pieces together right before Christmas 1973. Rowland knew enough about the photochemistry of chlorine and fluorine to suspect that, while CFCs would remain inert and stable in the troposphere, they would break down if they drifted into the stratosphere and absorbed short-wavelength UV radiation. With help from Molina, his postgraduate student, Rowland first began looking for natural CFC sinks, and found none: CFCs spent 40-150 years bouncing around the lower atmosphere without being absorbed by the ocean, rainwater, or chemical compounds in the air.[265] Lovelock's research showed that the amount of CFCs in the troposphere roughly equaled the total amount of CFCs ever produced, confirming the absence of any CFC sinks, so they went on to explore when CFCs started to break down from photo-absorption, and what was left behind. Rowland and Molina concluded that CFCs slowly diffused into the upper atmosphere, and the higher they drifted, the more shortwave UV they hit and the faster they broke down. CFCs photo-disassociated fastest in the region of the stratosphere with the highest ozone concentration (25-35 km), and when they broke apart, each CFC molecule left behind a free chlorine atom. Molina was familiar with laboratory experiments showing how chlorine destroyed ozone, and Rowland had twice invited Harold Johnston to present talks on the HOx and NOx catalytic reactions.[266] Once they realized that free chlorine atoms collide with ozone and reform in a similar ClOx cycle, it just came down to doing the math. Returning home from the break-through, Rowland greeted his wife, who casually wondered how the work was progressing. "The work is going well," he replied, "but it looks like the end of the world."[267] They had estimated

[265] F. S. Rowland and M. J. Molina. "Stratospheric sink for chloroflouromethanes: chlorine atomo-catalysed destruction of ozone." *Nature* 249 (June 28, 1974): 810-2.
[266] Seth Cagin and Philip Dray Pg. 170.
[267] Shari Roan. "The Man Who Saw the End of the World." *Orange County Register*. June 5, 1988.

ozone loss of twenty to forty percent in a century, leaving them sitting on the biggest story of their time.[268]

Writing up a draft of their findings for *Nature,* Rowland and Molina were well aware of what would happen once their research hit the press. The biggest uncertainty was not how CFCs could destroy ozone – that was basic photochemistry, and anyone who understood the HOx or NOx reactions immediately understood the ClOx cycle. The real question was how much chlorine would there be in the long-term future, once the rate at which CFCs circulated into the stratosphere (where they began to break down) caught up to the rate of emission. Millions of pounds of CFCs were being produced every year, and used in everything from refrigerators to seat cushions to hairspray. Printed in June 1974, their paper estimated that, given current production rates, atmospheric concentration of CFCs would reach ten to thirty times the present level and deplete total ozone by six percent.[269] If their research stood up to scrutiny, CFCs represented the largest and fastest growing source of stratospheric chlorine, and therefore the most deadly threat to ozone yet.[270]

- The spray can war

Surprisingly, Rowland and Molinas' paper was first met with disinterest – evidently the science had obscured the story. It broke after Rowland and Molina presented their findings at the annual American Chemical Society convention in Atlantic City.[271] Reviewing the growing body of research on the environmental and health costs of incremental ozone depletion – skin cancer, blindness, crop damage, genetic mutation, climate shifts – they argued that if the US continued to

[268] Paul Brodeur. "Annals of Chemistry: Inert." *The New Yorker*. April 2, 1975.
[269] F. S. Rowland and M. J. Molina.
[270] Paul Brodeur. "Annals of Chemistry: Inert."
[271] For a first hand recount of the public debate, see: F. S. Rowland and M. J. Molina. "Ozone Depletion: 20 Years After the Alarm." *Chemical and Engineering News* 72 (August 15, 1994): 8-13.

produce CFCs at their current rate, they would leave their children an altered planet, with ramifications far more complex than any they could truly predict.[272] They reasoned that the potential consequences of using CFCs far outweighed the economic advantages, and urged an immediate and total ban.

The proposed link between CFC production and ozone depletion received direct attention from government, industry, and media. Among those familiar with the ozone issue – then mostly academic and industry scientists, journalists, and environmental lobbyists – the findings sparked a firestorm of activity. The rest caught on as the theory gained recognition. On September 26, Walter Sullivan from *NYT* ran an article entitled "Tests Show Aerosol Gases May Pose Threat to Earth," in which he explained how the chemicals used in "hair sprays, insecticides and the like, while inert chemically, are highly efficient in promoting ozone break down."[273] Three days later, *The Chicago Times* printed a piece headlined "The aerosol can's threat is no joke," complete with a clear diagram showing how "life on earth is possible because the ozone shield blocks out most powerful ultraviolet radiation to prevent destruction of the planet's plants and organisms."[274] The editorials flooded in. One denounced the trade off between the fight against pollution and the fight against inflation.[275] Reflecting on every American's individual responsibility to confront the aerosol-ozone issue, another concluded, "the earth, seems less and less like a collection of different countries and more and more like a single, vast organism – the space ship that carries us all. It's increasingly clear that we'd better start learning how it works before we ruin it."[276] As the public realized basic household products could disrupt earth's

[272] Paul Brodeur. "Annals of Chemistry: Inert."
[273] Walter Sullivan. "Tests Show Aerosol Gases May Pose Threat to Earth." *The New York Times*. September 26, 1974.
[274] Ronald Kotulak. "The aerosol can's threat is no joke." *The Chicago Times*. September 29, 1974.
[275] William V. Shannon. "The Silent Threat." *The New York Times*. September 29, 1974.
[276] "Doomsday and the Aerosol." Editorial. *The Chicago Times*. October 13, 1974.

environmental balance, they turned to the issue with curiosity and caution. The children of the Cuban missile crisis immediately recognized the aerosol threat to the ozone layer. Steeped in the 1970s surge of environmental consciousness, they combated it with faith in the power of science and consumer demand.

The National Academy of Sciences "essentially became the scientific Supreme Court in the case of the fluorocarbon debate," and quickly appointed Rowland, McElroy and Johnston, to an ad hoc committee to define the problem and suggest a course of action.[277] Convening in Washington on October 26, they spent the day evaluating the science and discussing next steps. Despite their academic rivalries, the committee was markedly unified in its concern. Recognizing the economic impact of an immediate ban on CFC production, they agreed that "a year should be allowed for detailed discussion," and recommended forming an official panel of experts to conduct a comprehensive assessment of the problem.[278] However, they were clear that "If no missing factors are turned up by then, drastic action will probably be necessary because the effects mount rapidly with time."[279] The scientist heading the committee, Don Hunten from the Kitt Peak National Observatory in Arizona, was quoted in the *NYT* a week later urging people to stop buying aerosol cans immediately.[280] While he qualified his statement as personal opinion, most, if not all of the scientific community shared his sense of urgency. As Karim Ahmed, science advisor of the Natural Resources Defense Council (NRDC), reported in a December technical review, "There is an unprecedented consensus that the problem is extremely serious, and the highest priorities should be given to addressing the issue in the next year."[281]

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[277] Lydia Dotto and Harold Schiff. Pg. 199.
[278] Statement released by the NAS on October 24, 1974. Found in Lydia Dotto and Harold Schiff. Pg. 199.
[279] Ibid.
[280] Walter Sullivan. "Halt Urged in Buying Spray Cans That Might Hurt Ozone." *The New York Times*. October 31, 1974.
[281] Found in Seth Cagin and Phillip Dray. Pg. 192.

Anyone worried about CFCs destroying the ozone layer immediately focused their attention on the most obvious threat, aerosol spray cans. Used mostly to package hair sprays and deodorants, aerosol cans used over half of all CFCs produced in the US, and in 1973, 2.9 billion cans reached store shelves.[282] While other commercial products were designed to enclose the compounds, in refrigerators, plastics, cleaning solvents, etc., aerosol cans released them directly into the atmosphere. By the time Rowland and Molina published their discovery, aerosol cans made up seventy five percent of all US fluorocarbon emissions.[283] Seeking to tackle the biggest problem first, in November 1974 the NRDC submitted a petition to the Consumer Products Safety Commission (CPSC) to ban CFC aerosol spray propellants as hazardous products. In early December, two bills were introduced to restrict CFC aerosol production to essential-use only, and the first of many state and federal hearings began.[284] Mindful of the "adverse effects of regulatory legislation in a time of recession," Congress shot them down, but the aerosol issue was out there, and people began to pay attention.[285]

The spray can threat rapidly became a public concern, but Rowland, the NRDC, and others fighting to defend the ozone layer recognized that an American aerosol ban would only accomplish so much. The US accounted for half of all CFCs manufactured worldwide, and aerosols took up half of that. Eliminating spray cans left three fourths of global CFC production untouched. And, as they knew, the global total was all that really mattered. Leaving the press conference announcing the NRDC's petition, Rowland asked Karim Ahmed how long it would

[282] Lydia Dotto and Harold Schiff. Pg. 146.
[283] Ibid. Pg. 147.
[284] H.R. 17577, sponsored by Rogers and Esch, and H.R. 17545, sponsored by Aspin.
[285] Paul Brodeur. "Annals of Chemistry: In the Face of Doubt." *The New Yorker.* June 9, 1986.

take to get CFC production ended completely. "I think it looks like a fifteen year battle," he replied.[286]

While onlookers tended to see the fluorocarbon industry as "a single entity with a single goal," in reality it was more of a loose network of trade associations with varied and often competing interests.[287] By the 1970s, a wide range of firms had a stake in the commercial production of CFC aerosols. The marketing firms were the most visible, selling their brand of hair spray, perfume or deodorant in pharmacies and supermarkets nationwide. Then there were the assembly companies, which bought the valves, caps and labels from suppliers, mixed the marketer's product with CFC propellants and sold the final product – the packaged aerosol can – back to them. At the back of chain were the CFC manufacturers, selling their compounds to the aerosol assembly companies, along with refrigeration and air-conditioning companies, plastics and insulation manufacturers, any other firm that used CFCs in their trade. The diverse array of firms linked directly and indirectly to CFC production made it difficult to accurately assess the macro-economic stakes of any CFC regulation. But for any firm that based their profits on the "miracle compound," the stakes were high. In the fall of 1974, the Chemical Specialties Manufacturers Association organized seminar on the ozone problem: "perhaps the first attempt by industry to come to grips with the issue that was beginning to engulf them."[288] Addressing his peers, Igor Sobolev from the Kaiser Aluminum and Chemical Company reassured, "If you feel surprised, bewildered, and apprehensive about this, you are not alone."[289]

Of the six American CFC manufacturers, Du Pont was the largest, producing half of all the fluorocarbons used in the US. When the research broke connecting CFCs to ozone depletion,

[286] Seth Cagin and Philip Dray. Pg. 194.
[287] Lydia Dotto and Harold Schiff. Pg. 148.
[288] Ibid. 151.
[289] Ibid.

Du Pont had just finished putting the final touches on their brand-new, $100 million fluorocarbon plant in Texas, the largest in the world.[290] Not surprisingly, Du Pont spearheaded the fight to protect the American CFC market. The Chemical Manufacturer's Association (CMA) had been distributing research grants since 1972, and once Rowland and Molina's study surfaced, the industry responded by funding more science to clear up any uncertainty. At a congressional hearing in December 1974, Ray McCarthy guaranteed Congress that "if creditable scientific data developed in this experimental program show that any chloroflourocarbons cannot be used without a threat to health, Du Pont will stop production of these compounds."[291]

However, the scientific community still had more questions than answers about the ozone layer, and "creditable scientific data" was subject to interpretation. Oliver Taylor, a UC Riverside scientist receiving research funding from the CMA, immediately challenged the hypothesis that CFCs broke down when hit by shortwave UV radiation. He was on the fringe: the majority of independent scientists quickly subscribed to the growing body of evidence linking the ClOx reaction, ozone depletion, and adverse health effects.[292] But when people asked the scientific community for predictions or policy recommendations, most went only so far as to profess caution and uncertainty. The exact estimations of future damage were based on crude climate models with big blind spots, and many academics preferred retreating to their labs with grants to quietly patch the leaks in a theory that held water.

The collective body of knowledge on the ozone layer available to decision makers and the public was then still very limited, and the research sponsored by Du Pont, the CMA and other trade organizations definitely helped advance US understanding of the atmosphere's photochemical components. However, industry made much of this investment with the intention

[290] Ibid.
[291] Lydia Dotto and Harold Schiff. Pg. 180
[292] Seth Cagin and Philip Dray. Pg. 195.

of debating the issue into technical obscurity. The major CFC stakeholders bought time as they searched for profitable alternatives for their products, sponsoring every opportunity for scientists to get lost in the details. Rowland and the other scientists who began to speak out were met with a barrage of competing research from their peers.

As the experts compared numbers, those who made their living off CFCs went to the press, claiming that the picture was too blurry to warrant regulation. The Aerosol Education Bureau (AEB), an organization originally created to deal with the trend of teenagers inhaling aerosols to get high, managed public relations and propaganda. "All we have are assumptions," announced McCarthy in an AEB statement released on November 1, 1974.[293] Industry stakeholders also the poured money into the Council on Atmospheric Sciences (COAS), a strategically named coalition formed under the innocent pledge to gather "the data necessary to form the technical bases for legislation and executive decisions in the public interest."[294] In reality, COAS shuttled industry scientists and spokesmen around the country in a campaign of doubt.[295]

The fluorocarbon industry did its best to broadcast the growing consensus as a raging theoretical debate, with little concrete evidence to act upon. Capitalizing on uncertainty, the major CFC producers kept people sufficiently confused and discouraged by the ivory tower battles to ignore them, at least for a while. However, as the cards stacked up corroborating the link between CFCs and the destruction of life's vital sunshield, COAS found itself short of real experts who would willingly deny the validity of certain findings, including: (1) the circulation of CFCs through the troposphere and stratosphere, (2) the ozone-destroying ClOx reaction, and (3) the consequences of extreme ozone depletion. This led them to search out less-than-qualified

[293] "Industry Doubts Threat to Ozone." *The New York Times.* November 2, 1974.
[294] Ling-gee Gibney. "Federal Task Force Probes Ozone Issue." *Chemical and Engineering News*. March 10, 1975.
[295] Naomi Oreskes and Erik M. Conway. Pg. 107.

"experts" to spout skepticism in a futile attempt to hold up the process of consensus. One such man was Richard Scorer, a theoretical mechanics professor at the London's Imperial College of Science and Technology. Dismissing the Rowland-Molina theory as "utter nonsense," he arrived in the US in for a six-week summer speaking tour: "Scientists who widely promote 'scare' theories based on limited scientific evidence and legislators who overreact to those theories are threatening the jobs of thousands."[296] Citing the existence of natural chlorine in the atmosphere, he asserted that nature has handled itself in the past and can handle do so the future. [297]

Although Scorer's words reached the public's ears, a general sense of environmental caution, tied with a strong respect for scientific consensus largely displaced any fear of overreacting to the ozone risk. He and other industry doubt spreaders slowed Americans' reaction time, bogging them down in technical jargon, but they couldn't kill curiosity. And when Americans started looking into the subject, they saw a frivolous consumer product – the aerosol spray can – trying in vain to seem necessary as evidence piled up proving it was one of the greatest hazards of the twentieth century. Rowland responded to Scorer in the *Santa Ana Register*, "The gentleman is good at attacking, but he has never published any scientific papers on the subject."[298]

[296] Walter Sullivan. "Scientist Doubts Spray Cans Imperil Ozone Layer." *The New York Times*. July 8, 1975.
[297] Ibid.
[298] Ibid. August 1, 1975.

Existential Inconvenience

> "If the inert gas of chlorofluorocarbons in the spray can has the potential of destroying that precious layer of ozone… that filters the violent sun rays and shields every living thing, man and plant alike, then the proliferation of products sold in aerosol cans must rank with the atom bomb on the shopping list of man's travesties."[299]

- Atomic allusions

As industry launched its doubt campaign, the federal government took stock of the issue. Different regulatory bodies covered discrete sectors of the CFC market: the Food and Drug Administration controlled for food, drug and cosmetic uses of CFCs; the Environmental Protection Agency regulated pesticides; and the Consumer Product Safety Commission (CPSC) accounted for the waxes, polishes, cleaners, and other general household items.[300] This made it difficult to coordinate a unified federal response. In January 1975, President Ford set up an interagency task force, assigning individuals from seven Cabinet departments and five government agencies to jointly address the problem of Inadvertent Modification of the Stratosphere (IMOS). Working alongside with the NAS's new Panel on Atmospheric Chemistry, the IMOS panel convened throughout the spring, evaluating the problem with caution and curiosity. The experienced, peer reviewed scientists working on the issue, whether camped in industry and academia, shared a respect for the principles of the scientific method. All acknowledged uncertainties in their exact calculations, and if nothing else, called for more research before making any inferences that could overstep the evidence.

While Rowland and others stressed the high, unknown cost of sustaining current CFC production levels, McElroy believed that a total ban was drastic given the scientific uncertainties and the economic consequences. Testifying in the only public IMOS hearing on February 27,

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[299] Mardee de Wetter. "Give Our Earth a Stay of Execution." *Los Angeles Times*. June 14, 1975.
[300] Seth Cagin and Philip Dray. Pg. 193.

1975, Mike McElroy argued that a delay of CFC regulation wouldn't be fatal: "if we stop using chlorine compounds within five years we will not have done irreparable harm to the environment. That is not to say we must not get moving and take [CFCs] seriously."[301] His testimony helped solidify the belief that CFC production could continue for a few years, allowing the federal government to postpone regulation until the NAS finished their comprehensive review of the state of the science in late 1976.

McElroy chose to use his time in front of the IMOS panel to discuss a new chemical risk, bromides as a weapon of war. Bromides were a much faster scavenger of ozone molecules than hydrogen, nitrogen, or chlorine, and used in plastics manufacturing and crop fumigation.[302] McElroy worried that bromides, "if injected into the stratosphere in sufficient quantity… it would purge the ozone, permitting ultraviolet radiation from the sun to reach the ground with sufficient intensity to destroy crops and incapacitate the inhabitants."[303]

The scientific prosecutors of CFCs charged that he was distracting from the clearly more urgent problem. Like the coated nuclear bomb, a bromine weapon was entirely theoretical, and the impossibility of limiting its damage to a single enemy state made it strategically useless. The known chemicals that could scavenge ozone molecules – now hydrogen, nitrogen, chlorine – all were tied to important policy decisions, either over the SST program, the NASA shuttle, or the CFC industry. McElroy's peers felt he was simply harping bromine as an ozone threat to claim recognition for a new scientific breakthrough. In the *Science* the next month, Allen Hammond

[301] Lydia Dotto and Harold Schiff. Pg. 186.
[302] Seth Cagin and Philip Dray. Pg. 196.
[303] Walter Sullivan. "Ozone Depletion Seen as a War Tool." *The New York Times*. February 28, 1975.

critiqued the "alarmist statements" made by scientists who've caught "the smell of a Nobel Prize."[304]

Whether he intended to or not, McElroy was voicing a legitimate concern. The stratosphere's extreme vulnerability to chemical manipulation caught public attention. While the chlorine from CFC emissions would take years to filter into the stratosphere and damage the ozone layer, a small amount of bromine released over enemy territory could rapidly consume ozone and cause widespread devastation.[305] A sensational *National Enquirer* headline read "Harvard Professor Warns of… the Doomsday Weapon… It's Worse Than the Most Devastating Nuclear Explosion – and Available to All." McElroy was quoted claiming, "Any country in the world could handle it. And the terrifying thing is that right now, there's nothing to stop them."[306]

Ever since James McDonald stood in front of Congress and explained how particles in the stratosphere protected all life on earth from fatal UV sterilization, the ozone debate was wrapped in an aura of apocalypse that echoed America's fear of nuclear war. These two risks were closely intertwined, both in chemistry and perception. Three weeks before Rowland and Molina presented their findings to the public in Atlantic City, the Director of the Arms Control and Reduction Agency Fred C. Iklé gave a speech at the Council on Foreign Relations in Chicago entitled "Nuclear Disarmament without Secrecy." Iklé discussed how the Atomic Energy Commissions had been following on the academic research connecting SSTs and the NOx cycle ozone layer depletion. Nuclear weapons, when detonated, also released nitric oxide. Any substantial nuclear war could catastrophically affect ozone layer. Stressing the irreducible uncertainty inherent in their data, he explained:

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[304] Allen Hammond. "Ozone Destruction: Problem's Scope Grows, Its Urgency Recedes." *Science* (March 28, 1975): 1181.
[305] Found in: Lydia Dotto and Harold Schiff. Pg. 186.
[306] Ibid.

> We do not know how much ozone depletion would occur from a large number of nuclear weapons… We do not know how long such depletion would last… And above all, we do not know what this depletion would do to plants, animals and people. Perhaps it would merely increase the hazard of sunburn. Or perhaps it would destroy critical links in the intricate food chain of plants and animals, and thus shatter the ecological structure that permits man to remain alive on this planet.[307]

The Pentagon quickly responded to Iklé's announcement, claiming that a nuclear war could reduce stratospheric ozone concentrations by fifty to seventy-five percent, but "not to the point of endangering the continuance of life on earth."[308]

The ozone layer put clear scientific reasoning behind the possibility that "all-out nuclear war would lead to the wholesale destruction of life on earth."[309] The large-scale radiological damage of atomic weapons was known be catastrophic, but little open research had been performed to understand the long-term ecological effects of a war. As Iklé explained, the Pentagon's military technicians "tunnel along in complete seclusion with their untested systems and their unverified hypotheses about how they would fight a nuclear war, none aware of the disaster that is being prepared."[310] The cobalt bomb had dismissed as strategically "useless," and without access to full strike plans or nuclear test data, scientists couldn't dispassionately assess the health and biological damage of massive retaliation, a limited strike, or any other type of nuclear conflict the Pentagon had on file. Until the discovery of the nuclear-ozone risk, atomic extinction was science fiction, only as real as Nevil Schute's novel.

The ozone layer offered concerned scientists and civilians the evidence to prove how a total nuclear war directly threatened the survival of the entire human species. While the exact numbers needed to do the math remained confidential, the civil science of the stratosphere shed

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[307] John W. Finney. "U.S. Official Warns of Ozone Depletion from Nuclear War." *The New York Times*. September 6, 1974.
[308] John W. Finney. "Pentagon Replies on Peril to Ozone." *The New York Times*. October 17, 1974.
[309] John W. Finney. "Pentagon Replies on Peril to Ozone." The link between ozone depletion and nuclear war drove the research that would coalesce into the nuclear winter theory in the 1980s.
[310] "Middle America: Bombs." *New Scientist*. October 10, 1974.

light on the illogic of deterrence. Nitrogen released from nuclear explosions destroyed the ozone layer through the NOx cycle.

Each new discovery on the effects of nuclear explosions, from fire damage to radiation to ozone damage, "tore a hole in the facile assumptions that screen the reality of nuclear war."[311] Ozone depletion connected closed discussions of national security to open debates on environmental degradation. The growing body of public knowledge on nuclear risk forced government strategists to talk about national security terms of environmental science instead of military strike plans. As the prominent environmentalist Lester Brown wrote in 1977:

> The overwhelmingly military approach to national security is based on the assumption that the principal threat to security comes from other nations. But the threats to security may now arise less from the relationship of nation to nation and more from the relationship of man to nature. Dwindling reserves of oil and the deterioration of the earth's biological systems now threaten the security of nations everywhere. …In effect, the traditional military concept of "national" security is growing ever less adequate as nonmilitary threats grow more formidable.[312]

The risk of intentional ozone destruction as a military tactic received immediate attention. The House Subcommittee on International Organizations prepared a hearing and resolved that the US should seek an agreement with other members of the United Nations, most importantly the USSR, on "the prohibition of research, experimentation, or use of weather modification activity as a weapon of war."[313] As people from both nations tried to manage the growing fragility of the earth's biosphere, they began to realize the impracticality of maintaining their vast nuclear arsenals on launch ready alert. One editorial explained, "Recognition that the heavens should not be part of mankind's arsenal can lead to other prohibitions against the

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[311] Bryce Nelson. "U.S. Official Says Atomic War Could Ruin Earth's Ozone Shield." *Los Angeles Times*. September 8, 1974.
[312] Lester Brown. "Redefining National Security." Worldwatch Paper 14. *Worldwatch Institute* (October 1977).
[313] "Prohibition of Weather Modification as a Weapon of War." *Hearing before the House Subcommittee on International Organizations*. (Washington D.C., July 29, 1975).

insanity of nuclear warfare that would destroy the earth itself."[314] Stratospheric ozone was the ultimate deterrent, chemically insuring that any nation intending to rush into nuclear conflict would cause its own destruction along with everyone else's.

However, as McElroy explained in his testimony, it would take more than just restraint to guarantee collective survival in the face of existential risk. The bromine threat proved that anyone with time and money could learn how to destroy the world. It no longer required scientific super-ventures like the Manhattan project and the SST prototype, or a large-scale industry like aerosols to create the conditions for human extinction. Global ruin could now come from anyone with a basic handle on science and an irrational propensity for chaos: "the delivery would be no problem. A small rocket, an aircraft, even a balloon would do."[315] Human innovation was opening up the opportunity for small, non-state groups to wreak greater havoc than World War II, and many of the experts on the edge of scientific progress recognized the danger. Calling for an international treaty to mitigate a bromine ozone attack, McElroy was an early voice for the need to step past Cold War politics and collectively confront the real challenge of the twentieth century: minimizing the risk of a single actor – whether a state military, a non-state group, or an individual person – from doing something extremely dumb and potentially irreparable.

In October 1975, EPA administrator Russell Train spoke at NATO's round table committee on the challenges of modern society. Stratospheric ozone was "the first truly global environmental problem affecting each person and ecosystem on this planet."[316] Managing the risk of destroying it – from nuclear testing, stratospheric flight, space exploration, CFC production, bromine terrorism, or anything else – required long-term cooperation between all

[314] "Banning Weather War." *The New York Times*. September 2, 1975.
[315] Lydia Dotto and Harold Schiff. Pg. 186.
[316] Found in Seth Cagin and Philip Dray. Pg. 218.

state governments. The collective challenge put cracks in the ideological wall between the US and the Soviet Union; the two superpowers slowly found themselves spending more time confronting mutual threats than they did confronting each other.[317]

- Housewives' guilt

The press capitalized on the apocalyptic link between atomic war and ozone depletion. *Harper's Weekly* quickly equated the choice to use aerosol cans with the President's decision to release America's nuclear arsenal on the world. "Remember that each one of us can now 'push the button' on our own," it wrote. "Listen for that little whisper of doom."[318] In a March edition of *New Times* magazine, another article appeared, unsubtly titled "Not with a Bang, but with a Psssst!" The author claimed that "Aerosols have probably doomed more people than were killed by the atomic bomb dropped on Hiroshima," imagining a future in which "Farmers would have to plow what fields survived at night, while glaciers thousands of feet thick, leveled cities across Europe."[319]

Americans could see the path they were heading down, and had no trouble dreaming up how the world would end. "Is the homely aerosol spray can and its charge of propellant gas sowing the seeds of doomsday, threatening to destroy earth's ozone shield and bake the planet barren with solar radiation?" asked the Associated Press.[320] Since life had evolved in a perpetual struggle against the degenerative effects of UV radiation, "many organisms" were thought to be "living at the edge of their capability to protect themselves."[321] Any abrupt changes in ozone

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[317] Richard L. Homan. "Moscow, Washington Present Environmental Warfare Pact." *The Washington Post*. August 22, 1975.
[318] Found in: Lydia Dotto and Harold Schiff. Pg. 151.
[319] Micheal Drosnin. "Not with a Bang, but with a Psssst!" *New Times*. March 7, 1975. See also: Seth Cagin and Philip Dray. Pg. 204.
[320] Found in: Lydia Dotto and Harold Schiff. Pg. 152.
[321] Micheal Drosnin.

concentrations could threaten "a key link in the plant-animal food chain" – corn, plankton, rice, larvae – and send catastrophic shockwaves through an ecological network that the US clearly depended on, but barely understood.[322] "The earth may already have committed partial suicide or at least severe self-mutilation," proclaimed the *Philadelphia Inquirer*.[323]

Responding to an incremental, intergenerational crisis, citizens were acutely aware of their vulnerability, and saw the absurdity in waiting for proof that ozone depletion was collectively fatal before deciding to act. Pulitzer-prize winning satirist Russell Baker captured the irony of America's reaction to the existential ozone risk in a Sunday Observer article.[324] "We are gathered at home to watch the end of the world on television," he quipped.

> For months the networks have tried to persuade the world to end in prime time… No dice… Mother wants to watch CBS. She feels that so long as Walter Cronkite is handing the end of the world everything will turn out all right… There is an Exxon commercial. Exxon is working to build a better life for everyone after the end of the world.[325]

The family finally turns off the TV, and its so quiet that Baker can "hear the police steaming open my mail at the post office to make sure I still believe in the future of America."[326] Painting a quaint picture of a family's final night on the face of the earth, he concluded:

> Fragments of the last of the vitally essential ozone layer fall on the roof with the sound of small icicles breaking. The children plead to see the end of Abbott and Costello. Why not? They ought to have some way to remember the night the world ended, or else how will they ever believe it?[327]

Russell Baker's piece expressed an emerging recognition that the entire American lifestyle was based upon a collective naivety towards latent, catastrophic risks. While some of the American public still chose to wait for undeniable proof CFCs were hazardous, most were

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[322] Ibid.
[323] Found in: Lydia Dotto and Harold Schiff. Pg. 152.
[324] Russell Baker. "Sunday Observer: Ozone." *The New York Times*. March 2, 1975.
[325] Ibid.
[326] Ibid.
[327] Ibid.

already skeptical of blindly following technological progress, and quickly accepted that "man and his activities are having an effect on the upper atmosphere."[328] Given the ozone layer's importance, any effect was unacceptable. The possibility of global ruin, and their responsibility in causing it, overwhelmed any concern over the lack of exact data. The existential scale and intensity of the ozone risk triggered a collective dread response, and the public demanded action from government, industry, and each other.

As the CFC controversy grew into a common conversation, American citizens recognized that they were individually accountable for whether the world would grind to an apocalyptic halt or flourish as life's only known vessel in the cosmos. "While decisions about SSTs and nuclear bombs were out of their hands, decisions about spray cans were not."[329] Aerosols were a consumer product driven by collective demand. The power to extinguish civilization was no longer held to the White House, the Kremlin and their secret labs of chemists; it could now be found in every family's medicine cabinet. In June 1975, the *LAT* printed an editorial from Mardee de Wetter. The aerosol threat had her "housewife's world in disarray" as she came to grips with her agency in condemning the world to ecological anarchy. The average American family had forty to fifty aerosol cans in its cupboards. As Wetter wrote:

> Suddenly it wasn't a great, big anonymous "they" who were wrecking the world's future. It wasn't even the gadget's inventor. It wasn't the manufacturer or the companies whose products filled the containers. It was I, who continue to buy and use aerosol cans.
> For each product I will find an alternative. I believe in consumer power and I trust our housewives' good sense. Until we have absolute proof that the research to date is wrong, lets forgo our convenience and perhaps give our earth a stay of execution.[330]

The public's rejection of aerosols represented a shift in who was considered responsible for managing existential threats to the United States. From Kennedy's executive promise to

[328] George Alexander. "The Aerosol Threat to Our Atmosphere." *The Los Angeles Times*. April 27, 1975.
[329] Lydia Dotto and Harold Schiff. Pg. 3.
[330] Mardee de Wetter.

protect the US from nuclear extermination during the Cuban missile crisis, the challenge of securing a future worth living in grew to require every American's direct participation. As research proved that pushing the button on a spray can propelled the planet towards UV sterilization, citizens decided to stop buying them, choosing future-friendly vessels for their perfumes, hairsprays, deodorants, paints, and cleaners.

Considering the apocalyptic scale of the aerosol problem, solving it was astoundingly simple and painless. Industry made every effort to convince Americans that spray cans were irreplaceable, but as de Wetter made clear, they were nothing more than a convenience. And for product marketers, they were just a package. "Pump-tops, roll-ons, squeeze sprays and just plain bottles" quickly challenged aerosol cans as cheap and effective forms of packaging, and firms adapted.[331] Watching consumers forcefully reject aerosols as frivolous and harmful, marketers broke ranks with the coalition of CFC industry stakeholders. "Get off the can. Get on the stick," commanded one ad.[332] In an even more blatant innuendo, another featured "a debonair European male, with a blond clinging to him, telling his listeners how much he liked "The Pump."[333] By June 1975, CFC producers had cut output by twenty-five percent or more, and the fifth largest aerosol can manufacturer announced it was immediately eliminating fluorocarbons from its products to protect "the interest of our customers during a period of uncertainty and scientific inquiry."[334] The world's leading aerosol valve manufacturer, Precision Valve Company, temporarily closed its headquarters plant in New York after production fell by half.[335] As its

[331] Steven Greenhouse.
[332] Lydia Dotto and Harold Schiff. Pg. 168
[333] Ibid.
[334] Steven Greenhouse. See also: "Waxing Tough on Propellants." *The Washington Post*. June 19, 1975.
[335] "Sky Falling on Abplanalp Business." *The Los Angeles Times*. April 13, 1975.

owner Robert Abplanalp admitted, if Rowland and Molina's theory was true, "I've got no place to hide, nor do my kids."[336]

- End of the push-button age

The federal IMOS panel delivered its report on June 12, 1975. Reviewing the scientific consensus on human activity and the ozone layer, the report highlighted the remaining gaps in understanding and provided direction for future investigation. It also described the impacts of high-intensity UV exposure, considered potential CFC alternatives. Explaining how the EPA, FDA, and CPSC's had authority to control only specific aerosol products, the report argued that the current regulatory framework came far short of managing CFC production across all industries.[337] Acknowledging the link between CFC emissions and ozone depletion as a "legitimate cause for concern," the IMOS report recommended passing and implementing the Toxic Substances Control Act to provide the EPA with the power to regulate CFCs in all their uses. It concluded that "unless new scientific evidence is found to remove the cause for concern, it would seem necessary to restrict uses of (CFCs) 11 and 12… to closed recycled systems or other uses not involving release to the atmosphere."[338] Placing the burden of disproving their assessment on the NAS committee (its more extensive investigation was just getting underway), the IMOS report suggested that regulations could reasonably be effective by 1978.

While Washington waited on the elusive prospect of scientific certainty, Americans began regulating aerosols on their own. By the time IMOS delivered its report, legislators in thirteen states had introduced proposals to "ban, limit, or conduct research on fluorocarbon

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[336] Ibid.
[337] Walter Sullivan. "Federal Study Urges Ban on Some Aerosol Sprays." *The New York Times*. June 13, 1975.
[338] *Flourocarbons and the Environment: Report of Federal Task Force on Inadvertent Modification of the Stratosphere.* (Council on Environmental Quality: Washington D.C., 1975). Pg. 5.

aerosols.[339] Without debate, Maryland's Senate "sent to the House of Delegates a joint resolution decrying the use of aerosols with fluorocarbon propellant gases," while Oregon, New York and California moved forward with laws to regulate the sale of CFC products within state lines.[340] Acknowledging the holes in the scientific consensus, in June 1975, Oregon's Governor Robert Straub signed the first bill banning the sale of CFC-based aerosol products under the logic that he would rather "err on the side of caution."[341] Yet the federal government waited for the NAS to verify the science before taking any decisive action. Hesitant to regulate a flourishing industry during a period of national economic stagnation, decision-makers wanted to be sure the miracle compound was an imminent ozone threat before putting it down.

Left with the burden of confirming or denying the IMOS panel's indictment of CFCs, the NAS hoped to release their report in the spring of 1976. However, new findings threw a wrench into the gears of scientific consensus. Rowland and Molina's most recent experiments showed that chain reaction between chlorine and ozone molecules would "itself interact with the chain reaction taking place between ozone and naturally occurring nitrogen oxides."[342] The chlorine nitrate that formed would "temporarily disrupt the working of both chains, and prevent either one from depleting ozone as rapidly as each had been predicted to do alone."[343]

This new evidence led experts to worry about overstating the CFC threat and damaging their public credibility. The NAS committee postponed presenting their conclusions till September 1976, and their report was considerably less definitive than expected. They supported Rowland and Molina's ozone-depletion hypothesis, confirming that sustained CFC emissions

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[339] Steven Greenhouse. "Aerosol Feels the Ozone Effect." *The New York Times*. June 22, 1975.
[340] "Md. Seeks Ban of Aerosol Can." *The Washington Post*. March 6, 1975.
[341] Sharon Roan. *Ozone Crisis: The 15-Year Evolution of a Sudden Global Emergency.* (John Wiley: New York, 1989). Pg. 49. For a clear picture of US regulatory steps, see: Orval E. Nangle. "Stratospheric Ozone: United States Regulation of Chloroflourocarbons. *Boston College Environmental Affairs Law Review* 16, 3 (1989): 532.
[342] Paul Bordeur. "Annals of Chemistry: In the Face of Doubt"
[343] Ibid.

would eventually deplete up to fifty percent of stratospheric ozone, with huge rises in cases of skin cancer, large-scale plant and animal degeneration, and climatic changes from the greenhouse effect. However, when it came to recommending a course of action, the NAS checked itself. Regulation of CFCs was "almost certain to be necessary at some time and to some degree of completeness," but delaying the decision a couple of years would not result in "more than a fraction of a percent change in ozone depletion."[344] The ambiguous language of the report left lots of room for interpretation. The day after its release, *NYT* printed the story under the headline "Scientists Back New Aerosol Curbs to Protect Ozone In Atmosphere," while *The Washington Post* covered it as "Aerosol Ban Opposed by Science Unit."[345] The report was cited by activists and industry alike; each party lifted the parts that suited their argument and publicized them as the scientific verdict.

CFC stakeholders emphasized the harmlessness of a two-year regulatory delay, but few experts accepted this as a legitimate rational for ignoring the problem. At an international ozone conference held at Utah State University three days after the NAS released its report, James Anderson presented new research that concretely linked CFCs to ozone depletion. Test data from a balloon flight showed trace amounts of chlorine monoxide, one of the compounds left over from the ClOx reaction. The ratio aligned with computer model predictions. To those familiar with atmospheric chemistry, Anderson's discovery provided the "smoking gun" proving that the chlorine from CFCs had begun to react with ozone.[346]

Industry regarded the evidence as necessary but not sufficient for proving the theory. Then again, this was nothing new, as "the industry challenged the theory every step of the way.

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[344] National Academy of Sciences, Committee on the Impacts of Stratospheric Change. *Halocarbons: Environmental Effects of Chloroflouromethane Release.* (National Academy Press: Washington D.C., 1976). Pg. 7.
[345] Paul Brodeur. "Annals of Chemistry: In the Face of Doubt."
[346] Lydia Dotto and Harold Schiff. Pg. 228.

They said there was no proof that fluorocarbons even got into the stratosphere, no proof that they split apart to produce chlorine, no proof that, even if they did so, the chlorine was destroying ozone."[347] But for the vast majority of citizens, scientists and policymakers, the research to date was clear enough to act upon. At the Utah conference, an administrator from the EPA charged that requiring "body counts" before dictating public policy was unacceptable.[348] Foreshadowing the fight for an international regulatory regime for stratospheric ozone, Canadian and Norwegian officials announced their intention to restrict CFCs.[349] Russell Peterson delivered a strong speech prosecuting fluorocarbons and recommending immediate regulation. Peterson had worked at Du Pont for twenty-seven years and now headed the President's Council on Environmental Quality:

> From the pure scientific perspective, there remain valid doubts about the effect of fluorocarbons on the ozone shield. From the public-policy standpoint, however, there remains no valid reason to postpone the start of regulatory procedures… I believe firmly that we cannot afford to give chemicals the same constitutional rights that we enjoy under law. Chemicals are not innocent until proven guilty.[350]

On September 21, 1976, the federal IMOS committee originally tasked with directing government action on ozone issue met in Washington, where they voted unanimously to begin the process of eliminating CFCs in aerosols. With regulatory jurisdiction over eighty percent of the CFC-based aerosol products, the FDA was first to act.[351] Announcing the need for a phase-out plan for CFC propellants in food drugs and cosmetic products in mid-October, FDA commissioner Alexander Schmidt, explained the government's rational. "Given the effects on human health… it's a simple case of negligible benefit measured against possible catastrophic risk, both for individual citizens and for society. Our course of action seems clear beyond

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[347] Ibid. Pg. 225.
[348] Sharon Roan. *Ozone Crisis: The 15-Year Evolution of a Sudden Global Emergency*. Pg. 83.
[349] Edward Parson. Pg. 39.
[350] Seth Cagin and Philip Dray. Pg. 212.
[351] "U.S. to Propose Ban on Aerosol Sprays." *The Los Angeles Times*. October 15, 1976.

doubt."[352] That same month, Congress passed the Toxic Substance Control Act, giving the EPA the broad authority to test and regulate hazardous chemicals, including CFCs, across industry.[353]

The relative ease of designing alternatives, for the CFC propellant mix itself or the spray can package in general, meant that resistant companies quickly found themselves out-competed. Bob Abplanalp, whose Precision Valve Company had invented the CFC spray can valve and was one of the firms most entrenched in the CFC-aerosol industry, managed to turn around and announce a new propellant system in May that would meet "all government requirements."[354] The EPA began consolidating its control over CFCs, directing the transition to a full aerosol ban by the end of the decade. Du Pont, the world's biggest fluorocarbon manufacturer, barely felt it. By 1976, "the aerosol propellant business represented roughly 0.5 of its total sales," the rest going into the refrigerator, air conditioning, commercial food freezing and foam industries.[355]

The plan was to start to restrict the production of CFCs for aerosols by April 1977 and ban other forms of non-essential CFC use by June 1978.[356] The FDA, the EPA, and the CPSC worked through the winter to designed a phase-out plan that would direct industrial shift away from CFCs. Starting with an interim requirement that CFC-based aerosol products be labeled hazardous to public health and the environment, their goal was "to reduce use by voluntary action until such aerosols are phased out by mandatory regulation."[357] By the time the federal government announced its formal plan in the spring of 1977, CFC use in aerosol products had dropped seventy-five percent.[358]

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[352] "Phaseout Planned of Flourocarbons in Aerosol Sprays." *The Washington Post*. October 16, 1976.
[353] Mary Russell. "Ford Signs Bill on Toxic Substances." *The Washington Post*. October 13, 1976.
[354] Gene Smith. "Outwitting Aerosol Ban: New Systems Ready." *The New York Times*. May 13, 1977.
[355] Ibid.
[356] Edward Parson. Pg. 40.
[357] "'Hazardous to Earth': FDA wants warning on sprays." *The Chicago Tribune.* November 24, 1976.
[358] Naomi Oreskes and Erik M. Conway. Pg. 117.

A generation ago, consumers reveled in the prospect of push-button living, where the homemaker could virtually "sit back and take her ease while the work is done for her."[359] But the promise of endless convenience had been turned out to be empty. While dreaming of a Jetsons future, America had manufactured the chemicals needed to commit planetary suicide. For over a decade, they happily sprayed them into the air in the epitome of ironic ignorance. As one editorial articulated,

> If something tangible were to happen, maybe we'd wake up. But we can't SEE anything happening and on we go, fat, dumb and happy, spraying away, saving our fingers from the burden of having to pump a button on a deodorant can instead of pushing it once. It is black humor.[360]

Through the aerosol controversy, citizens solidified their collective belief in their dependence on the ozone shield, their power to destroy it, and their responsibility not to. While industry claimed that they always acted in the public interest, they would not stop producing CFCs until their consumer base forced them to. The rapid shift away from CFC spray cans came from a collective sense of urgency, voiced by experts and internalized by the public. The federal follow up simply put it in writing.

[359] Anne Douglass. "Foresees Age of Push Button for Housewife." *Chicago Daily Tribune*. January 14, 1950.
[360] Jack Mabley. "This answer's not blowin' in the wind." *Chicago Tribune.* March 16, 1975.

Cooperative Mitigation

> "It was generally accepted that changes in the ozone layer would pose serious risks to human health and the environment. The point of contention among the participating governments was the extent of international action necessary to provide a reasonable degree of protection."[361]

- Drag

Having won the push-button war, the American public went home to celebrate. They had collectively combated the greatest threat to the ozone layer, themselves. Aerosol spray cans had made up the brunt of CFC emissions, and the widespread consumer demand for a new way of packaging hairsprays, deodorants and cleaners forced industry to innovate and adapt. The NAS, continued to publish updates on the scientific consensus, but the US ozone war was over. Once the federal government announced its plans for regulation, the ozone issue largely fell off Americans' radar.

However, for academic scientists, EPA regulators, NRDC lawyers, and others working to prevent stratospheric ozone depletion, the American aerosol ban was the first step in global movement. The challenge of developing a worldwide scientific consensus on stratospheric chemistry strong enough to justify building a cooperative regulatory regime was daunting. The ozone layer was the ultimate global commons. CFCs were a key chemical component of economies around the world, and it was in the immediate interest of or any nation gaining from CFC production to avoid cooperative regulation. Countries that refused to participate in negotiations could continue to reap the benefits of a stable stratosphere while protecting a profitable domestic industry.

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[361] Richard Benedick. *Ozone Diplomacy: New Directions in Safeguarding the Planet.* (Harvard University Press: Cambridge, 1991). Pg. 22.

Under the same logic, ozone depletion represented a collective risk that required transnational dialogue, consensus, and action. Any single nation could damage the ozone layer, but all nations would suffer the consequences. The US would never be able to mitigate the risk of irreversible ozone damage without making sure every other government on the planet regulated their ozone-destroying innovations as well.

Under US encouragement, the United Nations Environmental Program (UNEP) hosted the first international conference on CFCs. UNEP was established five years earlier at the groundbreaking Stockholm Conference on the Human Environment, and was the institutional reflection of a budding global environmental consciousness. Located in Nairobi, Kenya, it embodied the challenge of ensuring an ecologically stable future for humanity's progeny without restricting all nations' right to economic progress and rising standards of living for their people. UNEP was ideally suited for managing the ozone risk. In the spring of 1977, representatives from the European Economic Community (EEC) – the precursor to the modern European Union – and thirty-three individual nations met in Washington to discuss how they would go about building a worldwide regulatory framework for CFCs and other industrial ozone threats.[362] Only Canada, Sweden, and Norway joined the US in pushing for an immediate, universal aerosol ban.[363] Germany promised to hold a follow-up conference in Munich a year later.[364]

The US was the driving force behind CFC creation and abolition. Its scientists invented them, companies manufactured them, and families bought them. In a tumultuous process of collective realization, Americans were the first connect the dots between human activity and stratospheric change and demand a vigorous, open research effort to understand the problem.

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[362] Seth Cagin and Philip Dray. Pg. 221.
[363] Joanne M. Kauffman. "Domestic and international linkages in global environmental politics: a case-study of the Montreal Protocol." Ed. Miranda A. Schreurs. *The Internationalization of Environmental Protection*. (Cambridge University Press: Cambridge, 1997). Pg. 77
[364] Seth Cagin and Philip Dray. Pg. 221.

Considering the possibility of catastrophic ozone damage, along with their direct responsibility in causing it, citizens developed an extremely conservative position on the ozone risk that weighed the health and environmental consequences of ozone depletion far greater than any conceivable economic or technological benefit. Living without spray cans was considered a minor inconvenience compared to planetary suicide, and the federal government followed the public's charge to eliminate the push-button threat. As Barbara Blum, the head of the early US delegation, declared at April 1980 meeting in Oslo, "Our country is moving forward now because we believe that chloroflourocarbons comprise one of the leading international environmental issues of the decade."[365]

Other countries did not feel the same way, nor did they have any reason to. In the UK, where the economic costs of an aerosol ban were steep, James Lovelock and other prominent scientists continued to argue that the US was panicking. The press coverage of the ozone issue was also less sensational, generating a much quieter call for collective action. Along with France, Britain led the European resistance to regulating CFCs, arguing that public awareness would shift the market off the chemicals without intervention.[366] None of the members of the EEC could regulate CFCs unilaterally, and were bound by treaty to establish a collective position before turning to any international negotiations.[367] Combined with Soviet Union, and Japan, who barely knew the ozone layer existed, the EEC accounted for two-thirds of the world's CFC production.[368] The global aerosol industry wasn't going anywhere.

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[365] Joanne M. Kauffman. Pg. 78.
[366] Ibid. Pg. 78. EEC aerosol use had fallen by thirty percent, but the worldwide production of CFCs showed no sign of abating.
[367] Seth Cagin and Philip Dray. Pg. 222.
[368] Richard Benedick. "Science, Diplomacy and the Montreal Protocol." Ed. Cutler J. Cleveland. *Encyclopedia of Earth.* (National Council for Science and the Environment: Washington, D.C, 2007).

The EEC began their debate over the scientific validity of ozone depletion and the economic ramifications of restriction, and the momentum for a rapid, worldwide CFC ban died. The EPA had intended to release a proposal for a second phase of regulations targeting non-aerosol CFC products in June 1978. They got to it two years later, but the Advanced Notice of Proposed Rulemaking was met with strong resistance from the wide range of business that depended on CFCs in some way. The spotlight on the ozone risk and CFC threat waned, and Du Pont quietly suspended research on CFC alternatives.[369]

Du Pont and other American CFC stakeholders used the need for an international consensus to justify a stall in the domestic ozone war. The fluorocarbon industry highlighted Europe's hesitation to enact an aerosol ban as evidence of America's overreaction. They argued that further regulations were impractical based on the scientific uncertainties and the economic consequences of leading by example. America still manufactured and consumed more CFCs than any other country in the world, but the hostile regulatory environment in the US had begun to push the bulk of the market across the Atlantic. DuPont lost one-third of its CFC business.[370] Without similar restrictions from rest of the world, stringent CFC regulation in the US would only damage the economy, while doing little to comprehensively deal with the risk of ozone depletion.

President Reagan took office in 1981, and his administration's vehement opposition to any form of government regulation signaled a domestic shift towards ozone indifference. The NSA and other scientific authorities lowered their figures of expected ozone depletion, and though the reports still warned of long-term catastrophic risk, the media paid little attention. The

[369] Seth Cagin and Philip Dray. Pg. 225.
[370] Joanne M. Kauffman. Pg. 78.

new EPA director Anne Buford considered the ozone layer a "non problem."[371] The EPA relaxed its timetable "thanks to a combination of public apathy," industry lobby power, and lack of leadership.[372]

- The sky is falling

However, the US decline in attention and concern didn't change physics. CFCs emitted over the past three decades continued to drift up to the stratosphere, break down from shortwave UV radiation, and deplete the ozone layer. While the shift off spray cans slowed CFC production for a few years, the growth of CFC use in refrigeration, cleaning agents, and foam insulation markets worldwide soon offset the decline of CFC production for aerosols.[373] In January 1982, twenty-four nations met in Stockholm and launched an Ad Hoc Working Group to prepare another, bigger meeting on ozone protection. Canada, Finland, Norway, Sweden and Switzerland formed the Toronto Group to advocate for a worldwide ban on nonessential CFC aerosol use, and began drafting the elements of a protocol. Convening in again Vienna in March 1985, forty-three nations established a framework for cooperative research and built momentum for future negotiations. While the EEC made clear it "was not even prepared to negotiate on any form of reduction of CFC production or use," they accepted the need for further investigation and discussion. In this sense, the Vienna Convention represented "the first effort of the international community formally to deal with an environmental danger before it erupted."[374]

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[371] Richard Benedick. "Science, Diplomacy and the Montreal Protocol."
[372] Paul Bordeur. "Annals of Chemistry: In the Face of Doubt"
[373] L. E. Manzer. "The CFC-Ozone Issue: Progress and Development of Alternatives to CFCs." *Science*, Vol. 249, No. 4964 (Jul. 6, 1990): 31-35.
[374] Richard Benedick. *Ozone Diplomacy: New Directions in Safeguarding the Planet.* (Harvard University Press: Cambridge, 1991). Pg. 45.

Ozone depletion was a long-term crisis, and in an open process of debate, the world's nations systematically responded to the data piling up in support of precautionary action. In the last moments of the Vienna Convention, the US and its allies introduced a resolution authorizing UNEP to reopen diplomatic negotiations, and if new findings demanded, set a 1987 target for a legally binding protocol. [375] This resolution set the stage for Montreal.

In May 1985, *Nature* published data from the British Antarctic Survey (BAS) released showing massive seasonal ozone loss over Antarctica, sparking a final round of debate, research, and action.[376] A NASA assessment had just finished a comprehensive report on the state of stratospheric science, leaving US experts relatively confident of their picture of the ozone layer. They initially dismissed the Survey's findings as an anomaly. If an ozone hole existed, NASA's satellite in orbit would have already detected it.[377] However, Richard Stolarski was curious, and decided to review NASA's data archive. In fact, the satellite had been collecting the same data as the BAS since it was launched in 1978, but the instruments were programmed to flag any readings outside the range of 180 to 650 Dobson Units as errors. The silent satellite data was a profound reminder of the limits of scientific research. Every tool was a telescope, showing some facts and missing others. By the end of 1985, ozone concentrations over the entire Antarctic were plunging sixty percent every October.[378]

The British Antarctic Survey's findings were a total surprise; no available scientific theory could properly explain the ozone hole.[379] While experts knew more about the stratosphere than ever before, they still suffered under the inexorable uncertainty of the material world.

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[375] Ibid.
[376] J. C. Farman, B. G. Gardiner, and J. D. Shanklin. "Large Losses of Total Ozone in Antartical Reveal Seasonal ClOx/NOx Interaction." *Nature* 315 (May 16, 1985): 207-10.
[377] Naomi Oreskes and Erik Conway. Pg. 119.
[378] Edward Parson. Pg. 85.
[379] Richard Stolarski, and others. "Nimbus 7 Satellite Measurements of the Springtime Antarctic Ozone Decrease." *Nature* 322 (August 28, 1986): 808-11.

NASA and NOAA immediately organized two missions to the Antarctic. They found that high levels of chlorine from CFC breakdown were depleting ozone in an accelerated ClOx reaction caused by polar stratospheric clouds.[380]

Until the hole over the Antarctic was uncovered, no scientific research had causally tied CFC emissions to observations of less stratospheric ozone. While evidence of chlorine monoxide in the atmosphere proved that CFCs were reacting with ozone compounds, no data had yet shown any significant drop in total ozone concentrations. Stratospheric ozone varied with latitude, season, and weather, circulating around the earth's surface in currents scientists could not accurately model. The difficulty of conclusively proving CFCs were a threat to stratospheric balance had justified industries call for more research before action. However, the ozone hole finally verified that CFCs were directly depleting ozone by showing how, "when the Sun rose in the Austral spring, chlorine concentrations became far higher than any model had predicted, and ozone levels fell far lower."[381]

The discovery did not influence the US negotiating position. NASA and NOAA scientists cautioned Richard Benedick, the chief US delegate to the Montreal Protocol, not to link the US stance on CFC regulation to the ozone hole, "lest conflicting evidence emerge that would undermine our general case for strong controls."[382] But the idea of a hole in the stratosphere was undeniably powerful, and it generated a surge of media attention and international momentum. While it wasn't an "immediate threat to worldwide ozone levels," scientists had no atmospheric model to explain or predict what was happening. A *Washington Post* headline warned, "Mysterious Annual Loss of Ozone Could Be Preclude to Wider Atmospheric Changes."[383]

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[380] Naomi Oreskes and Erik Conway. Pg. 121.
[381] Ibid.
[382] Richard Benedick. "Science, Diplomacy and the Montreal Protocol."
[383] "Scientists to Explore 'Hole' Over Antarctica." *The Washington Post*. June 23, 1986.

Some scientists worried that Antarctica's condition would expose America. "Polar Ozone 'Hole' May Occur Elsewhere," reported the *LAT*.[384] Humans were playing with the stratosphere, and scientists had little idea what would happen.

However, there was no doubt inaction would eventually be catastrophic. In September 1986, Du Pont declared its support for a global limit on CFCs. The industry leaders change in position was understandable: the ozone issue wasn't going away, alternative compounds could be manufactured, and a universal ban would end the European CFC industry's competitive advantage. Speaking for US fluorocarbon stakeholders, Richard Barnett announced, "on the basis of current information, we believe that large increases in fully halogenated CFCs… would be unacceptable to future generations."[385]

The State Department and the EPA worked hard through 1987 to build a broad baseline of knowledge on the ozone layer. US embassies around the world engaged their host countries in a continuous dialogue for ozone protection, and Washington dispatched high-level scientific missions to Japan and the Soviet Union to overcome their opposition to CFC controls. The US "even introduced their scientists to sophisticated aspects of U.S. satellite programs relevant to measuring trace gases."[386] Data exchange and information sharing through open science on the ozone layer was crucial to building confidence between the Cold War superpowers.

Despite opposition from his own party, President Reagan wholeheartedly endorsed the State Departments strong stance on CFC limits.[387] In September, 1987, the world's nations met in Montreal and agreed to freeze CFC production at 1986 levels in one year, followed by

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[384] Mark Landler. "Polar Ozone 'Hole' May Occur Elsewhere." *The Los Angeles Times*. October 21, 1986.
[385] Quoted in Edward Parson. Pg. 126.
[386] Richard Benedick. "Science, diplomacy, and the Montreal Protocol."
[387] This may be in part because the President had begun receiving treatment for skin cancer a few months earlier.

followed by a 20 percent reduction in by 1994 and a further cut to 50 percent by 1999.[388] Montreal represented a strong first step in global CFC regulation, and provided nations with the flexibility to reconvene and modify the treaty as new research came to light.[389]

In terms of global decision-making, the Protocol's balance of long-term risk with short-term gain was unprecedented. Evolving from early domestic concerns for human survival, it marked the culmination of a systematic process of research and debate in the face of uncertainty. Evidence of the ozone layers significance and fragility drove the US to lead the construction of the world's first international regime to protect an environmental commons, grounding a much broader effort to cooperatively manage human development in a changing climate.

[388] Richard Benedick. "Science, diplomacy, and the Montreal Protocol."
[389] The world's nations reconvened again in 1990 in London to increase restrictions.

Conclusion

> "Traditional notions of national sovereignty become questionable when local decisions and activities can affect the well-being of the entire planet."[390]

- Tipping points

The story of the US response to nuclear war and ozone depletion is the story of how humans realized they could create the conditions for their own extinction, and how that knowledge affected the behavior of countries at an international scale. The national response to nuclear and ozone risk was grounded in a firm collective understanding of America's agency in ending the world. As US and human extinction became a legitimate possibility, those responsible had to manage it, one way or another.

With the construction of the atom bomb, US scientists, journalists, leaders, and citizens faced the real possibility of disaster by decision. Nuclear weapons created a technical revolution in military force. By 1950, scientists had come to "the ironical conclusion that it becomes easier to kill all people in the world than just a part of them."[391] This realization marked the end of total war as a legitimate security strategy. During the Cuban missile crisis, US leaders confronted the reality of deterrence as they tried to prevent their military machine from careening out of control. Kennedy and Khrushchev both realized that they would have to practice military restraint if they wanted to leave their children a world worth living in.

Ozone depletion proved that restraint wasn't enough to prevent catastrophe. Managing the stratosphere's fragility required "far-ranging scientific, political, and economic cooperation" from every nation in the world.[392] Painfully aware of the stakes, the US led a systematic process

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[390] Ibid.
[391] Gerald Wendt. Pg. 151.
[392] Richard Benedick.

of scientific evaluation and public debate that convinced the world that CFCs were not worth the risk.

Nuclear war and ozone depletion are both stories of science. American academics were the first to perceive the scale, intensity, and urgency of these risks. The weight of the consequences pushed key experts to reject a purely descriptive scientific method and advocate for specific policy changes. The irreducible uncertainty of existential risk left many scientists convinced of their responsibility to inform the public. They believed the decisions to perform such global experiments should not be made in the dark, or in a dream. Civilian experts used science to shed light on the reality of nuclear massive retaliation and the illusion of spray can convenience. As they spoke out, their legitimate anxiety caught people's attention.

The fact that no one could know for sure what the earth would look like ten years after a nuclear war or fifty years after CFCs were eliminated demanded projects for further study. And the closer Americans looked at the real environmental consequences, the worse they seemed. Open evaluation of nuclear war was hindered by military secrecy, but by the late 1950s, it was clear that any conflict would be catastrophic. Investigations into the ozone layer in the 1970s finally gave the public's apocalyptic fears material traction. Stratospheric ozone was real, and it could be lost. Scientists established a strong consensus on (1) how indispensible the ozone layer was for life on earth, (2) what chemicals were we're destroying it, and (3) where they came from. Anyone with a sunburn and some sense of cause and effect could understand where ozone depletion was heading. Its direct consequences for human health and security informed the systematic response from the US government and the international community.

The US reaction to the risk of nuclear war and ozone depletion came down to a fear of tipping points. In the Cuban missile crisis, President Kennedy obsessed over the possibility of

one strategic anomaly from sparking a global nuclear war in a chain reaction. At the height of military tension, Kennedy was counting down the minutes to nuclear war, confident that, while he could not keep war at bay forever, he had to try. The impossibility of controlling a nuclear World War III left both the White House and the Kremlin imagining "many 'scenarios' for nuclear war that, far from being abstract and merely illustrative, were vividly concrete and terrifyingly real."[393] As James Blight explains, "American and Soviet leaders did imagine that the nuclear crystal ball was about to shatter, with the full knowledge that if their premonitions were realized, they would bear the responsibility for the worst catastrophe ever to befall mankind."[394]

In the ozone debate, the tipping points were imagined to be farther in the future. Scientists worried about the unknown stratospheric consequences fifty years down the line, after all the CFCs had drifted up through the troposphere to break down and consume ozone. The American spray can war was driven by an acute belief in the ozone layer's vulnerability to a wide range of known and unknown threats. SSTs, space shuttles, nuclear weapons, CFCs, bromine, and a host of other human innovations proved to endanger the earth's vital sun shield. With the discovery of the ozone hole, the possibility of a global ozone collapse brought a powerful sense of urgency, and the US worked to understand and mitigate the ozone risk before it was too late.

- Implications

The history of American perception of human extinction helps explain how US foreign policy has evolved over the second half of the twentieth century. The US military built its

[393] James G. Blight. *The Shattered Crystal Ball: Fear and Learning in the Cuban Missile Crisis*. (Roman & Littlefield: Maryland, 1990). Pg. 4.
[394] Ibid.

nuclear arsenal under the auspices of preventing the apocalypse. However, America's deterrent was protected from scientific scrutiny, since preventing a Soviet nuclear attack was matter of national security. International policy was "marked by the active adoption of strategic thinking under the influence of nuclear armament and the doctrines associated with it."[395] Fortunately Kennedy and Khrushchev recognized the fallacy of winning a nuclear war. Instead of applying the cold calculations of military deterrence, they worked from a sense of shared humanity in the face of existential risk.

America's open investigation into the stratosphere provided the scientific basis for a new foreign policy logic that understood the need for international cooperation to ensure survival. In the face of apocalyptic ozone depletion, the US quickly cut domestic CFC production, but the ozone problem could not be solved unilaterally. Convinced of the danger of naively spilling chemicals into the air, the US drove the international consensus to regulate the stratosphere. But the Montreal Protocol was not inevitable. It required consistent, hard work from US negotiators to educate and advocate the world on the dangers of ozone depletion. Its undeniable success shaped future international movements to comprehensively regulate the earth's natural services and mitigate the worst effects of climate change.

On May 14, 2012, *The New Yorker* published an article in their Annals of Science column on the current climate change debate entitled "The Climate Fixers: Is there a technological solution to global warming."[396] In his essay, Michael Specter clearly explains the scale of the risk and the actions policymakers are considering to mitigate it. Research teams in California and the UK have begun investigating methods of removing greenhouse from the

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[395] Wolf Mendl. "Strategic Thinking in Diplomacy: A Legacy of the Cold War." In *New Perspectives on Security*, edited by Michael Clarke. (Brassey's: London, 1993). Pg. 10.
[396] Michael Specter. "The Climate Fixers: Is there a technological solution to global warming?" *The New Yorker*. May 14, 2012.

atmosphere or, alternatively, reflecting sunlight from the earth with aerosol particles. These ideas, along with others that seek to intentionally reduce global warming (like placing huge mirrors across the Sahara or the Artic), are considered forms of "geoengineering": attempts to strategically alter earth's climate to the benefit of its people.[397]

While some interventions are relatively risk free (planting lots of trees, for instance), others carry more unknowns. As Harvard professor of engineering and public policy David Keith explains, "when you start to reflect light away from the planet, you can easily imagine a chain of events that would extinguish life on earth."[398]

Despite the possibility of inadvertently geoengineering into extinction, the consequences of not taking drastic action could be even worse. Experts do not know what humans have set in motion in terms of long-term ecological degradation, but they are convinced humans are collectively walking into a minefield. As climate scientists Ken Caldeira explains, "we just don't know where the minefield starts, or how long it will be before we find ourselves in the middle of it."[399] On a geological timescale, the spike in global carbon emissions from the industrial revolution onward is almost instantaneous. Humans are contributing to the sixth mass extinction in the planet's history, and critical ecosystem services are growing more vulnerable to seasonal climate fluctuations.[400] Around the world, "tens of thousands of wildfires have already been attributed to warming," along with extreme droughts, melting glaciers and sea level rise.[401]

US perception of climate change has only recently begun to take on the existential quality of nuclear war and ozone depletion. Its latency as an urgent public concern reflects the difficulty

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[397] Ibid.
[398] Quoted in: Ibid.
[399] Quoted in: Ibid.
[400] David B. Blake and Vance T. Vredenburg. "Are we in the midst of the sixth mass extinction? A view from the world of amphibians." *National Academy of Sciences* (August 12, 2008).
[401] Michael Specter.

of designing global policies in the face of scientific uncertainty and economic resistance. Climate change is a much more disparate risk than ozone depletion or nuclear war. It is understudied, multifaceted, and fossil fuel use is interwoven into the development of the industrial nation state. The questions are greater than ever, and so are the hurdles. To replace just a third of the fossil fuel power used around the world every year with "a source of energy that will not add carbon dioxide to the atmosphere… would require the construction of a new atomic plant every week for fifty years."[402] Americans cannot simply stop buying spray cans to solve the problem; mitigation requires redesigning energy infrastructure on a national and global scale.

The consequences of climate change are also less concretely apocalyptic. For the citizens of Tuvalu, climate change represents an immediate existential threat, as sea level rise has forced them to abandon their island homeland. However, for most US citizens, the risks associated with climate change are abstract and distant. In 1962, the consequences of Kennedy's decision would have been immediate, and Americans could easily imagine waking up to a world racked by nuclear war. For ozone depletion, the time horizon was about half a century, much farther in the future than an atomic holocaust, but close enough for US citizens to envision their children or grandchildren dying off from UV exposure. The consequences of climate change, however, may exist hundreds or thousands of years into the future. And for the most powerful country on the planet, there still is little reason to believe climate change is not adaptable. Until we grow acutely aware of our vulnerability, progress will be slow.

If the costs of climate change may still be considered opaque, its cause is clear. Nearly all scientists agree that the best and simplest solution would be to stop burning fossil fuels.[403] Even those working on geoengineering projects are vigorous advocates against their own work, since

[402] Ibid.
[403] Ibid.

any extreme intervention could have unintended and catastrophic side effects. For example, some of the compounds currently being considered for atmospheric injection, like sulfur dioxide, destroy the ozone layer. Aside from the known risks, there are always the unknowns, which, in the case of climate dynamics, are countless. Therefore, most scientists see geoengineering as a "false solution to an existential crisis – akin to encouraging a heart-attack patient to avoid exercise and continue to gobble fatty food while simply doubling his dose of Lipitor."[404] The only cure is ending emissions, anything less is just a temporary, and risky, treatment.

One of the most interesting aspects of the climate change debate is how the US national security apparatus has approached it. For most of the 20th century, the US military focused exclusively on winning wars, dismissing the environmental consequences as unfortunate byproducts of ensuring national security. The geopolitical realities of World War I, Pearl Harbor, World War II, the Berlin Wall and the Cuban Missile Crisis justified defining national security threats essentially, if not exclusively, in terms of a foreign country's military capacity. However, the emergence of non-military hazards like ozone depletion, along with the changing nature of armed conflict, has forced security scholars and policymakers to rethink what was actually a threat to national security, and whether traditional definitions were even applicable. As Gearóid Tuathail writes, in the last thirty years, Pentagon planners have begun to "conceptualize and operationalize how they should be dealing with informal warfare, failed states, proliferating toxic substances and peacekeeping operations in environmentally stressed region."[405] Security strategists have begun to worry about "hard" threat (transnational terrorist networks, rogue states and the proliferation of weapons of mass destruction) just as much as "soft" threats posed by

[404] Ibid.
[405] Gearóid Tuathail. "De-territorialized Threats and Global Dangers: Geopolitics, Risk Society and Reflexive Modernization." *Geopolitics* 3 (1) (1998): 17-31.

"global environmental problems (access to scarce resources, population pressures and environmental stress), international migration and violent ethnic nationalism."[406]

The Pentagon now recognizes the national security threat posed by climate change and environmental degradation, and has begun to call for serious investment in mitigation and alternative energy to prevent "threat multiplication."[407] The military's extremely high petroleum bill,[408] combined with estimates of oil shortages by 2015,[409] has also pushed the Pentagon to quietly lead the quest for renewable energy.[410] The Air Force is now the largest renewable energy power purchaser in the US, and third largest in the world.[411] Instead of the military being a problem, as it was in the nuclear arms race, it may well push open the door to a clean energy revolution.

Despite recent interest in clean technology, put in perspective, US strategic thinking still has a long way to go. In 2006, the US spent more on the war in Iraq than the entire world spent on renewable energy investment. The projected full costs of the Iraq War (about $3 trillion) would cover "all of the global investments in renewable power generation needed between now and 2030 to reverse global warming trends."[412] Military interventions also tend to cause massive ecological degradation, both on a local and global scale. If the war in Iraq was ranked as a country in terms of emissions, it would emit more CO2 each year than 139 (or 60 percent) of the

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[406] Ibid.
[407] See *National Security and the Threat of Climate Change*. The CNA Corporation's Military Advisory Board. 2007. <http://www.cna.org/reports/climate>; John M. Broder. "Climate Change Seen as Threat to U.S. Security. *The New York Times*. August 8, 2009. <http://www.nytimes.com/2009/08/09/science/earth/09climate.html?pagewanted=1>
[408] Steve Geisi. "Pentagon is investing in a greener military." *The Wall Street Journal*. August 24, 2011. <http://www.marketwatch.com/story/pentagon-is-investing-in-a-greener-military-2011-08-24>
[409] Terry Macalister. "US military warns oil output may dip causing massive shortages by 2015." *The Guardian*. April 11, 2010. <http://www.guardian.co.uk/business/2010/apr/11/peak-oil-production-supply>
[410] Sohbet Karbuz. "US military energy consumption- facts and figures." Energy Bulletin. *Post Carbon Institute.* May 20, 2007. <http://www.energybulletin.net/node/29925>
[411] Ibid.
[412]H. Patricia Hynes. "The US Military Assault on Global Climate." *Science for Peace Bulletin*. November 15, 2011. <http://www.scienceforpeace.ca/the-us-military-assault-on-global-climate>

world's nations do annually.[413] The total carbon emissions generated by U.S. military activity in the Middle East has raised the greenhouse gas intensity of gasoline made from imported Middle Eastern oil by 8 to 18 percent.[414] These estimates are conservative, given that emissions associated with war are "literally unreported."[415] Military emissions abroad are exempt from the greenhouse gas inventories that all industrialized nations report under the United Nations Framework Convention on Climate Change.[416] As Reisch and Kretzman write, it's "a loophole big enough to drive a tank through."[417]

The complexities of climate change, along with the scale of carbon-based energy worldwide, require renewed and expanded investment in collectively managing earth's commons. However, as our sustained military presence in the Middle East and our failure to ratify the Kyoto accords so far illustrates, the US is not yet ready to cooperate. We appear comfortable sitting on the sidelines as the rest of the world tackles the greatest challenge of the century: providing every person on the planet with enough energy to live in dignity without bankrupting the planet of the ecological systems all our children will need to survive.

Existential risks have left us a political world in which peaceful negotiation is a prerequisite to good foreign policy. The Cuban missile crisis and the Montreal Protocol are testaments to the necessity of investing in international communication and cooperation to prevent unintended disaster. In October 1962, power did not guarantee security. The inevitability of a nuclear accident pushed leaders from both the US and Soviet Union to replace their

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[413] Nikki Reisch and Steve Kretzmann. "A Climate of War: The war in Iraq and global warming." *Oil Change International*. March 2008.
[414] "Military Greenhouse Gas Emissions: EPA Should Recognize Environmental Impact of Protecting Foreign Oil, Researchers Urge." *Science Daily*. July 21, 2010. <http://www.sciencedaily.com/releases/2010/07/100721121657.htm>
[415] Nikki Reisch and Steve Kretzmann.
[416] H. Patricia Hynes. "The US Military Assault on Global Climate." *Science for Peace Bulletin*. November 15, 2011. http://www.scienceforpeace.ca/the-us-military-assault-on-global-climate
[417] Nikki Reisch and Steve Kretzmann.

antagonism with treaties to de-escalate, limit and control the arms race. With ozone-depleting aerosols, Americans realized markets can grow in the wrong direction, and took decisive collective action on a national and international level to help decide how countries should develop industrially. In both cases, short of relocating to the moon, Americans had no other choice but to reach out to other nations, define the problem, and fix it.

Climate change is no different. The US government cannot effectively protect its citizens from environmental degradation without collaborating with other countries. America cannot guarantee its long-term survival without solving its own emissions problem and convincing every other country in the world to do the same. The US can choose to lead that discussion and set the standard, as we have done in the past, or drag our feet at everyone's expense.

When will the US government stop prioritizing defense against terrorism over climate turmoil? As collective dread grows, how will the US government (or any other nation facing climate damage) choose which geoengineering policies to implement or outlaw? How will federally addressing climate change as an existential threat – urgent, direct, real – affect public perception, and vice versa? These questions reflect the uncertainty inherent in predicting social tipping points. Cultural cognition – the subconscious value system that comes from our individual relationships – has just as much influence on societal risk perception as scientific literacy. A recent study on public apathy over climate change reports:

> Public divisions over climate change stem not from the public's incomprehension of science but from a distinctive conflict of interest: between the personal interest individuals have in forming beliefs in line with those held by others with whom they share close ties and the collective one they all share in making use of the best available science to promote common welfare.[418]

[418] Dan M. Kahan and others. "The polarizing impact of science literacy and numeracy on perceived climate change risks." *Nature Climate Change* (May 27, 2012).

When climate change will shift from an abstract risk requiring little investment to an urgent threat demanding a major response is anyone's guess, but history helps us identify the signs. With the atom bomb and the ozone hole, a cycle of information and investment between experts, citizens, and policy-makers led to a clear picture of the risks, and a critical mass of people reacted. That cycle for climate change has begun. A risk perception survey of 580 leaders around the world identified climate change as one of the most likely and most damaging problems the world will face in the next ten years.[419] Further research would be needed to specify how that perception changes based on geographic location, domestic conditions, religious affiliation, political leanings, etc.

One of the leading theories on the cause of dinosaur extinction suggests that a large asteroid struck earth in a catastrophic explosion that dramatically altered the earth's surface temperature and killed off most plant and animal life. Through the risks of nuclear war and ozone depletion, Americans came to realize that we might be the asteroid that eliminates our species. That understanding has not disappeared. Climate change is an existential risk in that it is possible to create environmental conditions that we as a nation cannot reverse or adapt to. With enough tragedy and investigation, the American public will demand a comprehensive response, and the US government will be forced to work domestically and cooperate internationally in order to mitigate it. The question, then, is whether our collective process of realization will be fast enough, and our solutions smart enough to leave our posterity a world they in which they can flourish. So far, Americans have taken preventative action before tipping the world towards chaos. The inevitable consequences of ignoring climate change will bring the US back to the brink, and only time will tell if we rise to the challenge.

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[419] "Global Risks: 2011, Sixth Edition." *World Economic Forum* (Geneva, January 2011).

Bibliography

Acheson, Dean. "Dean Acheson's Version of Robert Kennedy's Version of the Cuban Missile Affair." *Esquire* (February 1969).

Adams, Ruth and Cullen, Susan ed. *The Final Epidemic: Physicians and Scientists on Nuclear War*. (Chicago, IL: Educational Foundation for Nuclear Science, 1981).

Adomeit, H. "Soviet risk-taking and crisis behavior: From confrontation to coexistence?" *The International Institute for Strategic Studies* Adelphi papers no. 101, 1973

Adomeit, H. *Soviet risk-taking and crisis behavior: A theoretical and empirical analysis*. (London: George Allen & Unwin, 1982).

"Aerosol hazard to atmospheric ozone." *New Scientist* 63 (September 26, 1974): 781.

Alexander, George. "The Aerosol Threat to Our Atmosphere." *The Los Angeles Times*. April 27, 1975.

Allison, Graham. *Essence of Decision: Explaining the Cuban missile crisis.* (Boston: Little Brown, 1971).

Alsop, Stewart. "Kennedy's Grand Strategy." *Saturday Evening Post* 235 (13) (March 31, 1962): 11-15.

Anderson, Peter J. *The Global Politics of Power, Justice and Death: An Introduction to International Relations.* (Routledge: New York, 1996).

Andersen, Ross. "Were Underestimating the Risk of Human Extinction." *The Atlantic*. March 6, 2012. <http://www.theatlantic.com/technology/archive/12/03/were-underestimating-the-risk-of-human-extinction/253821/#>

Aron, Raymond. *On War: Atomic Weapons and Global Diplomacy*. (Secker and Warburg: London, 1958).

Aron, Raymond. *Peace and War: a Theory of International Politics*. (Weidenfeld Nicolson: London, 1966).

Aslop, Joseph. "The Legacy of John F. Kennedy." *Saturday Evening Post* (November 21, 1964): 17.

Badash, Lawrence. *A Nuclear Winter's Tale*. (Cambridge, MA: The MIT Press, 2009).

Baldwin, David. "Neoliberalism, Neorealism, and World Politics." *Neorealism and Neoliberalism*, edited by David Baldwin. (Columbia University Press: New York, 1993).

Barnett, Michael and Duvall, Raymond. "Power in International Politics," *International Organization*, Vol. 59, No. 1, (Winter 2005).

Bates, David R. and Nicolet, Marcel. "The Photochemistry of Atmospheric Water Vapor." *Jorunal of Geophysical Research* Vol. 55, No. 3 (September 1950): 301-326.

"Banning Weather War." *The New York Times*. September 2, 1975.

Beck, Ulrich. *Risk Society: Towards a New Modernity*. (Sage: London, 1992).

Beck, Ulrich. *Reflexive Modernization: Politics, Tradition and Aesthetics in the Modern Social Order*. (Stanford University Press: Stanford, 1994).

Beck, Ulrich. *World Risk Society*. (Malden, MA: Blackwell Publishers, 1999).

Berkner, L.V. and Marshall, L. C. "On the Origin and Rise of Oxygen Concentration in the Earth's Atmosphere." *Journal of Atmospheric Sciences* Vol. 22, No. 3 (May 1965): 225-261.

Benedick, Richard. *Ozone Diplomacy: New Directions in Safeguarding the Planet.* (Harvard University Press: Cambridge, 1991).

Benedick, Richard. "Science, Diplomacy and the Montreal Protocol." Ed. Cutler J. Cleveland. *Encyclopedia of Earth.* (National Council for Science and the Environment: Washington, D.C, 2007).

Beschloss, Micheal R. *The Crisis Years: Kennedy and Khrushchev, 1960-1963.* (HarperCollins: New York, 1991).

"Biological and Environmental Effects of Nuclear War." *Hearings before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy*. (Washington D.C.: June 22-26, 1959).

Blake, David B. and Vredenburg, Vance T. "Are we in the midst of the sixth mass extinction? A view from the world of amphibians." *National Academy of Sciences* (August 12, 2008).

Blegen, Bryce. "International Cooperation in Protection of Stratospheric Ozone." *Denver Journal of International Law* Winter/Spring (1988): 413-28

Blight, James G. and Welch, David A. *On the Brink: Americans and Soviets Reexamine the Cuban Missile Crisis*. (Hill and Wang: New York, 1989).

Blight, James G. *The Shattered Crystal Ball: Fear and Learning in the Cuban Missile Crisis*. (Roman & Littlefield: Maryland, 1990).

Bohlen, Charles E. *Witness to History, 1929-1969*. (W. W. Norton: New York, 1973).

Booth, Ken. "Critical Explorations." In *Critical Security Studies and World Politics*, edited by Ken Booth. (Lynne Rienner: Boulder CO, 2005).

Bostrom, Nick. "Existential Risks: Analyzing Human Extinction Scenarios and Related Hazards." *Journal of Evolution and Technology*, Vol. 9, March 2002. <http://www.nickbostrom.com/existential/risks.html>

Brewer, A. W. "Evidence for a World Circulation Provided by the Measurements of Helium and Water Vapour Distributions in the Stratosphere." *Quarterly Journal of the Royal Meteorological Society* 75 (1949): 351-63.

Brown, Lester. "Redefining National Security." Worldwatch Paper 14. *Worldwatch Institute* (October 1977).

Brians, Paul. *Nuclear Holocausts: Atomic War in Fiction, 1895-1984.* (Kent State University Press: London, 1987).

Brodeur, Paul. "Annals of Chemistry: Inert." *The New Yorker*. April 2, 1975.

Brodeur, Paul. "Annals of Chemistry: In the Face of Doubt." *The New Yorker.* June 9, 1986

Brodie, Bernard. "Strategic Bombing: What It Can Do." *The Reporter*. August 15, 1950.

Brodie, Bernard. "Changing Capabilities and War Objectives." Lecture. Air War College, April 17, 1952. *Bernard Brodie Papers*, Box 12, UCLA.

Brown, Lester. "Redefining National Security." Worldwatch Paper 14. *Worldwatch Institute* (October 1977).

Broder, John M. "Climate Change Seen as Threat to U.S. Security. *The New York Times*. August 8, 2009.

Brugioni Dino A. *Eyeball to Eyeball: The Inside Story of the Cuban Missile Crisis*. Robert F. McCort ed. (Random House: New York, 1990).

Bundy, McGeorge. *Danger and Survival: Choices About the Bomb in the First Fifty Years*. (Random House: New York, 1988).

Burgman, M.A., Ferson, S. and Akcaya, H.R. *Risk Assessment in Conservation Biology*. (Chapman & Hall: London, 1993).

Buzan, Barry. *People, States & Fear: The National Security Problem in International Relations*. (Harvester Wheatsheaf: Brighton, 1983).

Buzan, Barry, Wæver, Ole and Wilde, Jaap de. *Security: A New Framework for Analysis.* (Lynne Rienner: Boulder Publishers, 1998).

Buzan, Barry and Hansen, Lene. *The Evolution of International Security Studies*. (Cambridge University Press: Cambridge, 2009).

Campbell, Scott and Currie, Greg. "Against Beck: In Defence of Risk Analysis." *Philosophy of the Social Sciences* 36, no. 2 (June 1, 2006): 149-172

Cambone, Stephen. *A New Structure for National Security Policy Planning.* (CSIS: Washington D.C., 1998).

Cavelty, Myriam Dunn. "From Threats to Risks in International Security – and Subsequent Challenges for 'Knowing' the Future." *International Relations and Security Network*. November 16, 2011. http://www.isn.ethz.ch/isn/Current-Affairs/Special-Feature/Detail?lng=en&id=134110&contextid774=134110&contextid775=134111&tabid=134111

Chang, Laurence and Kornbluh, Peter, ed. *The Cuban Missile Crisis, 1962: a documents reader*. (The New Press: New York, 1992).

Cicerone, Ralph and others. "Assessment of Possible Environmental Effects of Space Shuttle Operations." *NASA CR-129003* (June 3, 1973).

Cicerone, Ralph J., Richard S. Stolarski and S. Walters. "Stratospheric Ozone Destruction by Man-Made Chlorofluorocarbons." *Science* 185 (1974):1165-68.

Clapton, William. "Risk in International Relations." *International Relations* 25 3 (2011): 280–295.

Clifton, C.V. "Memorandum of Conference With President Kennedy." *USAF*. (Washington D.C.: September 20, 1961).

CQ Fact Sheet on John F. Kennedy, (Congressional Quarterly: Washington D. C., 1960).

"Cobalt Bomb Declared Unpractical as Weapon." *The Los Angeles Times*. April 12, 1954.

Cohen, Avner, and Lee, Steven. *Nuclear Weapons and the Future of Humanity: The Fundamental Questions*. (Totowa, N.J: Rowman & Allanheld, 1986).

Comte, Auguste. *A General View of Positivism*, translated by J.H. Bridges (Trubner and Co., 1865) Reissued by Cambridge University Press, 2009.Durkheim, Emile. *The Rules of the Sociological Method*, translated by Steven Lukes. (Simon and Schuster Inc.: New York, 1982).

Cox, Wayne S. and Sjolander, Claire T. "Critical Reflections on International Relations." In *Beyond Positivism: Critical Reflections on International Relations*, edited by Wayne S. Cox and Claire T. Sjolander. (Lynne Rienner: London, 1994).

Crutzen, Paul J.. "The influence of nitrogen oxides on the atmosphere ozone content." *Quarterly Journal of the Royal Meteorological Society*, 96, (1970): 320-5.

Deutsch, Karl and others. *Political Community and the North Atlantic Area*. (Princeton University Press: Princeton, 1957).

Deudney, Daniel. "The Case Against Linking Environmental Degradation and National Security." *Millennium*, Vol. 19, No. 3. (1990): 461-76. Gilpin, Robert. *American Scientists and Nuclear Weapons Policy*. (Princeton University Press: Princeton, 1962).

Devetak, Richard. *Theories of International Relations*. (Palgrave MacMillan: New York, 2005).

de Wetter, Mardee. "Give Our Earth a Stay of Execution." *Los Angeles Times*. June 14, 1975.

Dobbs, Michael. *One Minute to Midnight: Kennedy, Khrushchev, and Castro on the brink of nuclear war.* (Alfred A. Knopf: New York, 2008).

Dobson, G. M. "Origin and Distribution of Polyatomic Molecules in Atmosphere." *Proceedings of the Royal Society* A236: 187-93.

"Doomsday and the Aerosol." Editorial. *The Chicago Times*. October 13, 1974.

Dotto, Lydia, and Schiff, Harold. *The Ozone War*. (New York, N.Y.: Double Day, 1978).

Douglass, Anne. "Foresees Age of Push Button for Housewife." *Chicago Daily Tribune*. January 14, 1950.

Dulles, John Foster. Speech. Council on Foreign Relations, January 12, 1954. *Documents on American Foreign Relations* (1954).

Duranty, Walter. "United States recognizes Soviet, exacting pledge on propaganda; Bullitt named first ambassador." *The New York Times*. November 17, 1933.

Elliot, T.S. "The Hollow Men." *Collected Poems, 1909-1962*. (Harcourt Brace Jovanovich: New York, 1991).

Ellman, Michael and Maksudov, S. "Soviet Deaths in the Great Patriotic War: A Note." *Europe-Asia Studies* 46, (4) (1994): 671-680.

"Explosion!" *The New York Times*. September 25, 1949.

Farman, J. C., Gardiner, B. G., and Shanklin, J. D. "Large Losses of Total Ozone in Antartical Reveal Seasonal ClOx/NOx Interaction." *Nature* 315 (May 16, 1985): 207-10.

Federal Civil Defense Administration, "Facts About Fallout" (U.S. Government Printing Office: Washington, D.C., 1955).

Finnemore, Martha. *National Interests in International Society*. (Cornell University Press: Ithaca, 1996).

Finney, John W. "U.S. Official Warns of Ozone Depletion from Nuclear War." *The New York Times*. September 6, 1974.

Finney, John W. "Pentagon Replies on Peril to Ozone." *The New York Times*. October 17, 1974.

Flourocarbons and the Environment: Report of Federal Task Force on Inadvertent Modification of the Stratosphere. (Council on Environmental Quality: Washington D.C., 1975).

Fursenkom, Alexandr and Naftali, Timothy. *One Hell of a Gamble: Khrushchev, Castro, and Kennedy.* (W. W. Norton: New York, 1997).

Gaberson, William. "Behind Du Pont's Shift on Loss of Ozone Layer." *New York Times*. March 27, 1988.

Gaddis, John Lewis. *Russia, the Soviet Union and the United States, An Interpretative History*. (McGraw-Hill: New York, 1990).

Garrison, Dee. *Bracing for Armageddon: Why Civil Defense Never Worked*. (Oxford University Press: New York, 2006). Pg. 22.

Geisi, Steve. "Pentagon is investing in a greener military." *The Wall Street Journal*. August 24, 2011. <http://www.marketwatch.com/story/pentagon-is-investing-in-a-greener-military-2011-08-24>

Geist, Edward Moore. *Scenarios for Survival: Representations of Nuclear War in American and Soviet Civil Defense Manuals, 1954-1972.* University of North Carolina at Chapel Hill. Masters Thesis. 2008.

George, Alice L. *Awaiting Armageddon: How Americans Faced the Cuban Missile Crisis*. (Chapel Hill: University of North Carolina Press, 2003).

Gibney, Ling-gee. "Federal Task Force Probes Ozone Issue." *Chemical and Engineering News*. March 10, 1975.

Gibson, John E. "The Case Against the Supersonic Transport." *Harper's Magazine* (July 1966).

Glasstone, Samuel ed. *The Effects of Nuclear Weapons*. (Washington D.C.: United States Atomic Energy Commission, 1957).

"Global Risks: 2011, Sixth Edition." *World Economic Forum* (Geneva, January 2011).

Gosling, F.G. "The Manhattan Project: Making the Atomic Bomb." *United States Department of Energy*. January 1999.

Greenhouse, Steven. "Aerosol Feels the Ozone Effect." *The New York Times*. June 22, 1975.

Gribkov, Anatoli I. and Smith, William Y. *Operation ANADYR: U.S. and Soviet Generals Recount the Cuban Missile Crisis*. (Edition Q: Chicago, 1994).

Hammond, Allen. "Ozone Destruction: Problem's Scope Grows, Its Urgency Recedes." *Science* (March 28, 1975): 1181.

Haynes, John Earl and Klehr, Harvey. *Venona: Decoding Soviet Espionage in America*. (Yale University Press: London, 2000).

"'Hazardous to Earth': FDA wants warning on sprays." *The Chicago Tribune.* November 24, 1976.

Hiroshima: The Decision to Drop the Bomb. TV documentary produced by Fred Freed, NBC. 1965.

Hiroshima & Nagasaki Remembered. National Science Digital Library. 2005. <http://www.hiroshima-remembered.com/history/hiroshima/page8.html>

"History of the Joint Strategic Target Planning Staff: Preparation of SIOP-63." Strategic Air Command, History and Research Division. January 1964. Declassified February 2007.

History of the Custody and Deployment of Nuclear Weapons: July 1945 through September 1977. (Office of the Assistant to the Secretary of Defense (Atomic Energy): Washington D.C., 1978).

Holifield, Chet. "Congressional Hearings on Radioactive Fall-out." *Bulletin of the Atomic Scientists*, Vol. 14 (1) (January 1958).

Homan, Richard L. "Moscow, Washington Present Environmental Warfare Pact." *The Washington Post*. August 22, 1975.

Horwitch, Mel. *Clipped Wings: The American SST Conflict*. (MIT Press: Cambridge, 1982).

Hunt, B. G. "The Need for a Modified Photochemical Theory of the Ozonosphere." *Journal of the Atmospheric Sciences* Vol. 23 (Jan 1966): 88-95.

Hynes, H. Patricia. "The US Military Assault on Global Climate." *Science for Peace Bulletin*. November 15, 2011. <http://www.scienceforpeace.ca/the-us-military-assault-on-global-climate>

"Hysteria Ousts Science from Halocarbon Controversy." *New Scientist*. June 19, 1975.

Fluorocarbons and the Environment: Report of the Federal Task Force on Inadvertent Modification of the Stratosphere. (Federal Task Force on Inadvertent Modification of the Stratosphere: Washington, D.C.: Government Printing Office, 1975)

"Implications of Soviet Possession of Atomic Weapons." A report by the Joint Intelligence Committee to the Joint Chiefs of Staff. JCS 2081/1, Feb. 13, 1950, CCS 471.6 U.S.S.R. (11-8-49), section 1, Papers of the United States Joint Chiefs of Staff.

"Industry Doubts Threat to Ozone." *The New York Times.* November 2, 1974.

Jarvis, Darryl S. L. "Theorising Risk and Uncertainty in International Relations: The Contributions of Frank Knight." *International Relations* 25 (3) (September 5, 2011): 296-312.

Jervis, Robert. *Perception and Misperception of International Politics*. (Princeton University Press: Princeton, 1976).

Jervis, Robert. *The Illogic of American Nuclear Strategy*. (Cornell University Press: Ithaca, 1984).

"John F. Kennedy's Voting Record and Stands on Issues." *John F. Kennedy Presidential Library and Museum.* <http://www.jfklibrary.org/Research/Ready-Reference/JFK-Miscellaneous-Information/Voting-Record-and-Stands-on-Issues-Page-6.aspx>

Johnston, Harold S. "Reduction of Stratospheric Ozone by Nitrogen Oxide Catalysts from Supersonic Transport Exhaust." *Science* 173, (August 6, 1971): 517-22.

Johnston, Harold S. "Atmospheric Ozone." *Annual Review of Physical Chemistry* 43 (October 1992): 1-32.

Jones, Robin Russell and Wigley, Tom ed. *Ozone Depletion: Health and Environmental Consequences.* (John Wiley & Sons: New York, 1989)

Kahan, Dan M. and others. "The polarizing impact of science literacy and numeracy on perceived climate change risks." *Nature Climate Change* (May 27, 2012).

Kahn, Herman. *On Thermonuclear War.* (Princeton University Press: New York, 1960).

Kaplan, Fred. "JFK's First Strike Plan." *The Atlantic Monthly*. (October 2001). <http://www.theatlantic.com/past/docs/issues/2001/10/kaplan.htm>

Kaplan, Fred. *The Wizards of Armageddon.* (Simon and Schuster: New York, 1983).

Karbuz, Sohbet. "US military energy consumption- facts and figures." Energy Bulletin. *Post Carbon Institute.* May 20, 2007. <http://www.energybulletin.net/node/29925>

Kennan, George F. "The Sources of Soviet Conduct." *Foreign Affairs* (July 1947).

Kennedy, John F. "Address to the United Nations General Assembly." (September 25, 1961). *John F. Kennedy Presidential Library and Museum.* <http://www.jfklibrary.org/Asset-Viewer/Archives/JFKPOF-035-048.aspx>

Kennedy, John F. "Aid for Greece and Turkey." (April 1, 1947). *Record of the House of Representatives*.

Kennedy, John F. "Announcement of Candidacy for President." (Washington, D.C., January 2, 1960). *John F. Kennedy Presidential Library and Museum.* <http://www.jfklibrary.org/Research/Ready-Reference/JFK-Miscellaneous-Information/Announcement-of-Candidacy.aspx>

Kennedy, John F. "Radio and Television Report to the American People on the Soviet Arms Buildup in Cuba." (Washington D.C., October 22, 1962). *John F. Kennedy Presidential Library and Museum.* <http://www.jfklibrary.org/Asset-Viewer/sUVmCh-sB0moLfrBcaHaSg.aspx>

Kennedy, John F. Review of B.H. Liddell Hart's "Deterrent or Defense." *Saturday Review of Literature*. (September 3, 1960).

Kennedy, John F. Speech. (Mormon Tabernacle, Salt Lake City, September 23, 1960). *John F. Kennedy Presidential Library and Museum.* <http://www.jfklibrary.org/Research/Ready-Reference/JFK-Speeches/Remarks-of-Senator-John-F-Kennedy-at-Mormon-Tabernacle-Salt-Lake-City-Utah-September-23-1960.aspx>

Kennedy, John F. Speech. (Democratic Dinner, Cincinnati, Ohio, October 6, 1960). *John F. Kennedy Presidential Library and Museum.* <http://www.jfklibrary.org/Research/Ready-Reference/JFK-Speeches/Remarks-of-Senator-John-F-Kennedy-at-Democratic-Dinner-Cincinnati-Ohio-October-6-1960.aspx>

Kennedy, John F. *Commencement Address at American University*. Washington D.C. June 10, 1963.

Kennedy, Robert F. *Thirteen Days: A memoir of the Cuban missile crisis.* (W. W. Norton & Company, Inc.: New York, 1968).

Kotulak, Ronald. "The aerosol can's threat is no joke." *The Chicago Times*. September 29, 1974.

Landler, Mark. "Polar Ozone 'Hole' May Occur Elsewhere." *The Los Angeles Times*. October 21, 1986.

Laurence, William. "Ending of All Life by Hydrogen Bomb Held a Possibility." *The New York Times*. February 27, 1950.

Laurence, William L. *The Hell Bomb.* (Alfred A. Knopf: New York, 1951).

"Leaders mourn Soviet wartime dead." *BBC News*. May 9, 2005. <http://news.bbc.co.uk/2/hi/europe/4530565.stm>

"Letter from Jacqueline Kennedy to Chairman Khrushchev." December 1, 1963. Ed. Thomas Fench. *The Kennedy-Khrushchev Letters.* (New Century Books: The Woodlands, 2001).

"Life of John F. Kennedy." *John F. Kennedy Presidential Library and Museum.* <http://www.jfklibrary.org/JFK/Life-of-John-F-Kennedy.aspx?p=5>

Litfin Karen T. *Ozone Discourses: Science and Politics in Global Environmental Cooperation.* (Columbia University Press: New York, 1994).

Lovelock, James E. "Atmospheric Fluorine Compounds as Indicators of Air Movements." *Nature* 230 (April 9, 1971): 379.

Lovelock, James E. and others. "Halogenated Hydrocarbons In and Over the Atlantic." *Nature* 241 (1973): 194-6.

Lynch, Allen. "Political and Military Implications of the 'Nuclear Winter' Theory." *Institute for East-West Security Studies,* Occasional Paper Series 5 (1987).

Mabley, Jack. "This answer's not blowin' in the wind." *The Chicago Tribune.* March 16, 1975.

Macalister, Terry. "US military warns oil output may dip causing massive shortages by 2015." *The Guardian*. April 11, 2010. <http://www.guardian.co.uk/business/2010/apr/11/peak-oil-production-supply>

Malik, John. "The Yields of the Hiroshima and Nagasaki Explosions." *Los Alamos National Laboratory.* September 1985.

Mahnken, Thomas G. "Strategic Theory." In *Strategy in the Contemporary World*, edited by John Baylis, James J. Wirth, and Colin S. Gray. (Oxford University Press: London, 2007).

Manzer, L. E. "The CFC-Ozone Issue: Progress and Development of Alternatives to CFCs." *Science*, Vol. 249, No. 4964 (Jul. 6, 1990): 31-35.

Mathews, Jessica Tuchman. "Redefining Security." *Foreign Affairs*, Vol. 68, No. 2. (1989): 162-177.

McAuliffe, Mary ed. *CIA Documents on the Cuban Missile Crisis 1962*. (Central Intelligence Agency: Washington D.C., 1992).

McDonald, James. "Civil Supersonic Aircraft Development. Continuing Appropriations." *Hearing before the House Subcommittee on DOT Appropriations* (Washington D.C., March 1, 1971).

McElroy, Michael B. and Wofsy, Steven C. "HOx, NOx, and ClOx: Their Role in Atmospheric Photochemistry." *Canadian Journal of Chemistry* 52 (8) (April 15, 1974): 1582-1591.

McGrath, W. D., and Norrish, R. G. W. "Studies of the Reactions of Excited Oxygen Atoms and Molecules Produced in the Flash Photolysis of Ozone." *Proceedings of the Royal Society* 254 (1278) (February 23, 1960): 317-326.

McNeill, J. R. *Something New Under the Sun: An Environmental History of the Twentieth-Century World.* (W. W. Norton: New York, 2001).

"Md. Seeks Ban of Aerosol Can." *The Washington Post*. March 6, 1975.

Mendl, Wolf. "Strategic Thinking in Diplomacy: A Legacy of the Cold War." In *New Perspectives on Security*, edited by Michael Clarke. (Brassey's: London, 1993).

Memorandum. *NSC Series*, Box 13, Ann Whitman File, DDEL. (December 22, 1960).

Menand, Louis. "Fat Man: Herman Kahn and the nuclear age." *The New Yorker* (June 27, 2005). <http://www.newyorker.com/archive/2005/06/27/050627crbo_books?currentPage=all>

"Middle America: Bombs." *New Scientist*. October 10, 1974.

"Military Greenhouse Gas Emissions: EPA Should Recognize Environmental Impact of Protecting Foreign Oil, Researchers Urge." *Science Daily*. July 21, 2010. <http://www.sciencedaily.com/releases/2010/07/100721121657.htm>

Mulligan, Joseph F. "Who were Fabry and Pérot." *American Journal of Physics* 66 (9) (September 1998): 797-802.

Naftali, Timothy and Zelikow, Philip. *The Presidential Recordings: John F. Kennedy Vol. 1-3, The Great Crisis.* (W. W. Norton: New York, 2001).

Nangle, Orval E. "Stratospheric Ozone: United States Regulation of Chloroflourocarbons. *Boston College Environmental Affairs Law Review* 16, 3 (1989): 532.

National Academy of Sciences, Committee on the Impacts of Stratospheric Change. *Halocarbons: Environmental Effects of Chloroflouromethane Release.* (National Academy Press: Washington D.C., 1976).

National Research Council. *Long-term Worldwide Effects of Multiple Nuclear Weapons Detonations.* (Washington, D.C.: National Academy of Sciences, 1975).

National Security and the Threat of Climate Change. The CNA Corporation's Military Advisory Board. 2007. <http://www.cna.org/reports/climate>

Nelson, Bryce. "U.S. Official Says Atomic War Could Ruin Earth's Ozone Shield." *Los Angeles Times*. September 8, 1974.

Neufeld, Jacob. *Ballistic Missiles in the United States Air Force, 1945-1960*. (Office of Air Force History: Washington, D.C., 1989)

"Nixon Fires Barrage; Jack Plugs Social Issue." *Milwaukee Sentinel*. (October 23, 1960).

North, Robert C. *War, Peace, Survival: Global Politics and Conceptual Synthesis*. (Westview Press: Boulder, CO, 1990).

O'Donnell, Kenneth P. and Powers. David F. "*Johnny, We hardly Knew Ye": Memories of John Fitzgerald* Kennedy. (Little Brown: Boston, 1972).

Office of Technology Assessment. *The Effects of Nuclear War*. (Washington, D.C.: U.S. Government Printing Office, 1979).

Oreskes, Naomi and Conway, Erik. *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming.* (New York, NY, Bloomsbury Press, 2010). Pg.

Parson, Edward. *Protecting the Ozone Layer: Science and Strategy*. (Oxford University Press: New York, 2003).

Pedlow, Gregory W. and Welzenbach, Donald E. *The CIA and the U-2 Program, 1954-1974*. (CIA Center for the Study of Intelligence: Washington D.C., 1998).

"Phaseout Planned of Flourocarbons in Aerosol Sprays." *The Washington Post*. October 16, 1976.

Piccard, Auguste. "Ballooning in the Stratosphere: Two Balloon Ascents to Ten-Mile Altitudes Presage New Mode of Aerial Travel." *National Geographic* 63 3(March 1933).

Polmar, Norman and Gresham, John D. *DEFCON-2: Standing on the brink of nuclear war during the Cuban missile crisis.* (John Wiley & Sons, Inc.: Hoboken, 2006).

Postel, Sandra. "Altering the Earth's Chemistry: Assessing the Risks." Worldwatch Paper 71. *World Watch Institute*, (1986).

"Prohibition of Weather Modification as a Weapon of War." *Hearing before the House Subcommittee on International Organizations* (Washington D.C., July 29, 1975).

Reeves, Richard. *President Kennedy: Profile of Power.* (Simon & Schuster: New York, 1994).

Reisch, Nikki and Kretzmann, Steve. "A Climate of War: The war in Iraq and global warming." *Oil Change International*. March 2008.

Rhodes, Richard. *The Making of the Atomic Bomb*. (Simon & Schuster: New York, 1986).

Roan, Sharon. "The Man Who Saw the End of the World." *Orange County Register*. June 5, 1988.

Roan, Sharon. *Ozone Crisis: The 15-Year Evolution of a Sudden Global Emergency.* (John Wiley: New York, 1989).

Roman, Peter J. "Ike's Hair Trigger: U.S. Nuclear Predelegation, 1952-1960." *Security Studies*, 7:4 (1998). Pg. 121-164.

Rosenberg, David Alan. "American Atomic Strategy and the Hydrogen Bomb Decision." *The Journal of American History*, Vol. 66 (1) (June, 1979). Pg. 62-87.

Rosenberg, David Alan. "The Origins of Overkill: Nuclear Weapons and American Strategy, 1945-1960." *International Security*, Vol. 7 (4) (Spring, 1983). Pg. 3-71.

Rowland, F. S. and Molina, M. J. "Stratospheric sink for chloroflouromethanes: chlorine atomo-catalysed destruction of ozone." *Nature* 249 (June 28, 1974): 810-2.

Rowland, F. S. and Molina, M. J. "Ozone Depletion: 20 Years After the Alarm." *Chemical and Engineering News* 72 (August 15, 1994): 8-13.

Rumsfeld, Donald. DoD News Briefing - Secretary Rumsfeld and Gen. Myers. News Transcript. February 12, 2002

Russell, Mary. "Ford Signs Bill on Toxic Substances." *The Washington Post*. October 13, 1976.

Sagan, Scott D. "SIOP-61: The Nuclear War Plan Briefing to President Kennedy." *International Security* Vol. 12, No. 1 (Summer, 1987). Pg. 22-51.

Sandberg, Anders, Matheny, Jason and Cirkovic, Milan. "How can we reduce the risk of human extinction?" *Bulletin of the Atomic Scientists*. September 9, 2008. <http://www.thebulletin.org/web-edition/features/how-can-we-reduce-the-risk-of-human-extinction>

Saunders, Harold H. "An Historic Challenge to Rethink How Nations Relate." In *The Psychodynamics of International Relationships, Vol. I: Concepts and Theories*, edited by Vamik D. Volkan, Demetrios A. Julius, and Joseph V. Montville. (Lexington Books: Lexington, MA, 1990).

Schwartz, P. and Randall, D. *An abrupt climate change scenario and its implications for United States national security*. (New York: Environmental Defense, 2003).

Schelling, Thomas C. "An Astonishing Sixty Years: The Legacy of Hiroshima." (Nobel Prize Lecture held at Beijersalen, The Royal Swedish Academy of Sciences. Stockholm, Sweden, December 8, 2005).

Schute, Neville. *On the Beach.* (Heinemann: London, 1957).

Science News. "End of Aerosol Age? Federal Report Says Probable." Science News 21 (June, 1975).

"Scientists Warn of World Suicide." *The Los Angeles Times*. February 27, 1950.

"Scientists to Explore 'Hole' Over Antarctica." *The Washington Post*. June 23, 1986.

Shalett, Sidney. “First Atomic Bomb Dropped on Japan; Missile Is Equal to 20,000 Tons of TNT; Truman Warns Foe of a ‘Rain of Ruin.’” *The New York Times*. August 6, 1945. <http://www.nytimes.com/learning/general/onthisday/big/0806.html>

Shannon, William V. “The Silent Threat.” *The New York Times*. September 29, 1974

Shea, Cynthia Pollock. Protecting Life on Earth: Steps to Save the Ozone Layer." *Worldwatch Institute*, Worldwatch Paper 87 (1988).

Sheehan, Micheal. “The Evolution of Modern Warfare.” In *Strategy in the Contemporary World*, edited by John Baylis, James J. Wirth, and Colin S. Gray. (Oxford University Press: London, 2007).

“Sky Falling on Abplanalp Business.” *The Los Angeles Times*. April 13, 1975.

Smith, Gene. “Outwitting Aerosol Ban: New Systems Ready.” *The New York Times*. May 13, 1977.

Smith, Micheal E. *International Security: Politics, Policy, Prospects.* (Palgrave Macmillan: New York, 2010).

Smith, Steve. “The Increasing Insecurity of Security Studies: Conceptualizing Security in the Last Twenty Years.” In *Critical Reflections on Security and Change*, edited by Stuart Croft and Terry Terriff. (Frank Cass: London, 2000).

Smith, William Y. “Memorandum for General Taylor: Strategic Air Planning and Berlin.” *USAF*. (September 7, 1961).

Smyth, Henry DeWolf. *Atomic Energy for Military Purposes: The Official Report on the Development of the Atomic Bomb under the Auspices of the United States Government ,1940-1945.* (Princeton: Princeton University Press, 1945).

Sokolski, Henry D., Ed. *Getting MAD: Nuclear Mutual Assured Destruction, its Origins and Practice.* (Strategic Studies Institute: November 2004).

Solomon, Fred and Marston, Robert Q., Ed. *The Medical Implications of Nuclear War*. (National Academy Press: Washington, D.C., 1986).

Sorensen*,* Theodore. *Kennedy*. (Harper & Row: New York, 1965).

Specter, Michael. “The Climate Fixers: Is there a technological solution to global warming?” *The New Yorker*. May 14, 2012.

Stalin, J.V. *Works* Vol. 10. (Foreign Languages Publishing House: Moscow, 1954).

Stimson, Henry L. “The Decision to Use the Atomic Bomb.” *Harper’s Magazine*. (February 1947).

Stine, Deborah D. “The Manhattan Project, the Apollo Program, and Federal Energy Technology R&D Programs: A Comparative Analysis.” *Congressional Research Service.* June 20, 2009.

Stipp, D. ‘The Pentagon’s weather nightmare: the climate could change radically, and fast. That would be the mother of all national security issues.” *Fortune*. Feb. 2004.

Stern, Sheldon M. *Averting “the Final Failure”: John F. Kennedy and the Secret Cuban Missile Crisis Meetings.* (Stanford University Press: Stanford, 2003).

Stindl, Reinhard. “Is Telomere Erosion a Mechanism of Species Extinction.” *Journal of Experimental Zoology* (2004): 111-120.

Sullivan, Walter. "Sorry, but There's Still More to Say on The SST: Ozone." *The New York Times*. May 30, 1971.

Sullivan, Walter. "Halt Urged in Buying Spray Cans That Might Hurt Ozone." *The New York Times*. October 31, 1974.

Sullivan, Walter. "Ozone Depletion Seen as a War Tool." *The New York Times*. February 28, 1975.

Sullivan, Walter. "Scientist Doubts Spray Cans Imperil Ozone Layer." *The New York Times*. July 8, 1975.

Sullivan, Walter. "Federal Study Urges Ban on Some Aerosol Sprays." *The New York Times*. June 13, 1975.

"Survival Muddle: Civil Defense Planners Push Ahead Furiously – In Divergent Dirctions." *The Wall Street Journal*. February 12, 1958.

Szasz, Ferenc Morton. *British Scientists and the Manhattan Project*. (St. Martin's Press: New York, 1992).

Szilard, Leo. "A Petition to the President of the United States." First draft. July 3, 1945. Edward Teller. Letter to Leo Szilard. July 4, 1945. <http://www.atomicarchive.com/Docs/ManhattanProject/SzilardTeller2.shtml>

Teller, Edward, Konopinski, Emil and Marvin, C. "LA-602: Ignition of the Atmosphere with Nuclear Bombs." (Declassified July 30, 1979). <http://www.fas.org/sgp/othergov/doe/lanl/docs1/00329010.pdf>

Teller, Edward. "How Dangerous Are Atomic Weapons?" *Bulletin of the Atomic Scientists*, Vol. 3 (2) (February 1947).

"The Economics of Climate Change: A Primer." *Congressional Budget Office*. April 2003. <http://www.cbo.gov/publication/14387>

The Effects on the Atmosphere of a Major Nuclear Exchange (Washington, D.C.: The National Academies Press, 1985).

The Fog of War. Film Documentary. Directed by Errol Morris (Sony Pictures Classics, 2003).

"The Lift of a Driving SST." *The Washington Post*. March 23, 1971.

Tillman, Barrett. *LeMay*. (Palgrave Macmillan: New York, 2007).

Tuathail, Gearóid. "De-territorialized Threats and Global Dangers: Geopolitics, Risk Society and Reflexive Modernization." *Geopolitics* 3 (1) (1998): 17-31.

Tolba, Mostafa K. 1987a. "Nowhere To Hide." UNEP mimeo. Statement to the Ad Hoc Working Group for the Preparation of a Protocol on CFCs, Third Session. Geneva, April 1987.

"U.S. Strategic Bombing Survey: The Effects of the Atomic Bombings of Hiroshima and Nagasaki." *President's Secretary's File, Truman Papers.* June 19, 1946. Found in the Harry S. Truman Library. <http://www.trumanlibrary.org/whistlestop/study_collections/bomb/large/documents/index.php?pagenumber=2&documentdate=1946-06-19&documentid=65&studycollectionid=abomb>

"U.S. to Propose Ban on Aerosol Sprays." *The Los Angeles Times*. October 15, 1976.

Vertzberger, Yaacov Y. I. "Rethinking and Reconceptualizing Risk in Foreign Policy Decision-Making: A Sociocognitive Approach." *Political Psychology*, vol. 16, no. 2 (June 1995): 347-380.

Vertzberger, Yaacov Y. I. "*Risk Taking and Decision Making: Foreign Military Intervention Decisions.* (Stanford University Press: Stanford, 1998).

Wæver. Ole. “Securitization and Desecuritization.” In *On Security*, edited by Ronnie Lipschutz. (Columbia University Press: New York, 1995): 46-86.

“Waxing Tough on Propellants.” *The Washington Post*. June 19, 1975.

Weart, Spencer R. *Nuclear Fear: A History of Images.* (Harvard University Press: Cambridge, 1988).

Weisskopf, Michael. “CFCs: Rise and Fall of Chemical ‘Miracle’; Chlorofluorocarbons vs. Ozone.” *The Washington Post* (April 10, 1988).

Wendt, Alexander. “Anarchy is what states make of it: the social construction of power politics.” *International Organization*, Vol. 46, No. 2 (Spring 1992): 391-425.

Wendt, Gerald. *Atomic Energy and The Hydrogen Bomb*. (Medill McBride: New York, 1950).

Wolfers, Arnold. “National Security as an Ambiguous Symbol.” *Political Science Quarterly,* Vol. 67, No. 4 (December 1952).

World’s End – Maybe.” *The New York Times.* February 28, 1950.

Zubok, Vladislav and Pleshakov, Constantine. *Inside the Kremlin’s Cold War: From Stalin to Khrushchev.* (Harvard University Press: Cambridge, 1996).

Zuckerman, Edward. *The Day After World War III*. (The Viking Press: New York, 1984).

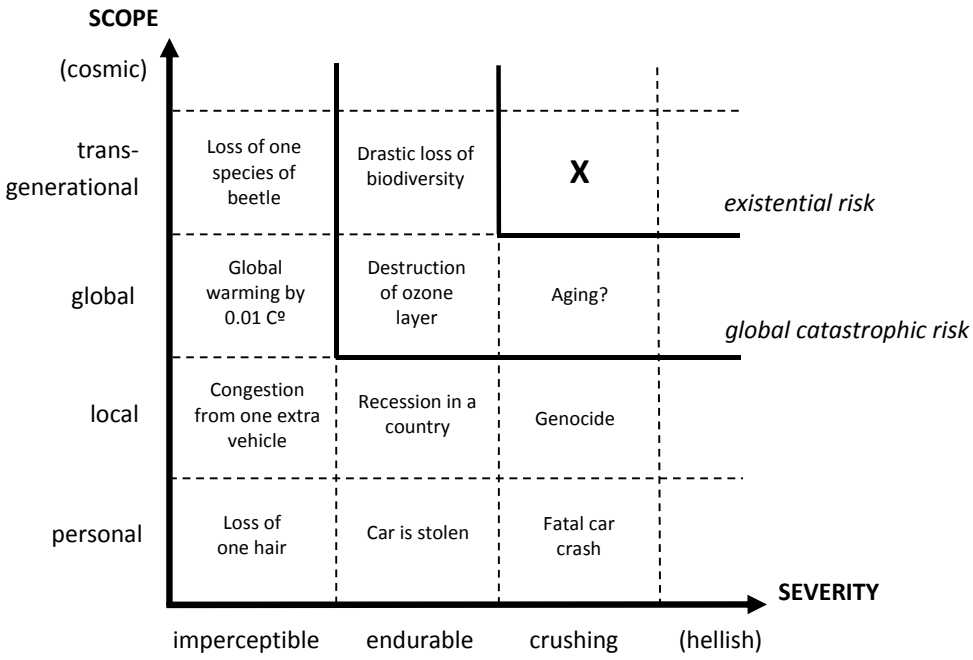
Appendix

Figure 1: Timeline of Events

October 1941 –	FDR approves Manhattan Project
January 1945 –	Teller and Konopinski and Marvin evaluate the risk of human extinction in "LA-602: Ignition of the Atmosphere with Nuclear Bombs"
July 1945 –	The "Trinity" test successfully detonates first atomic bomb
August 1945 –	US atomic bombs fall on Hiroshima and Nagasaki
December 1945 –	*Bulletin of the Atomic Scientists* founded
June 1947	The *Bulletin* sets first Doomsday Clock at seven minutes to midnight
April 1947 –	Congressman John F. Kennedy warns Americans of nuclear extermination in a total war with the USSR
June 1948 –	Berlin airlift begins
October 1948 –	LeMay takes charge of the SAC
April 1949 –	The US, France, the UK, Canada and others form NATO
August 1949 –	The USSR detonates its first atomic bomb
February 1950 –	Bethe, Szilard, Brown and Seitz introduce the theoretical cobalt bomb
June 1950 –	US enters the Korean War
November 1952 –	First US H-bomb "Mike" is successfully detonated
June 1953 –	Ethel and Julius Rosenberg executed for espionage
August 1953 –	First Soviet H-bomb test
March 1954 –	Castle Bravo test alerts US public to dangers of nuclear radiation
April 1954 –	US military confirms cobalt bomb could be built
April 1957 –	Nevil Schute publishes *On the Beach*
May 1957 –	Congressional hearings begin on radioactive fallout and biological effects of nuclear war
September 1957 –	The Soviet Union launches *Sputnik 1*
January 1960 –	Herman Kahn publishes *On Thermonuclear War*
April 1961 -	SIOP-62 enters into effect
June 1961 –	The USSR erects the Berlin Wall

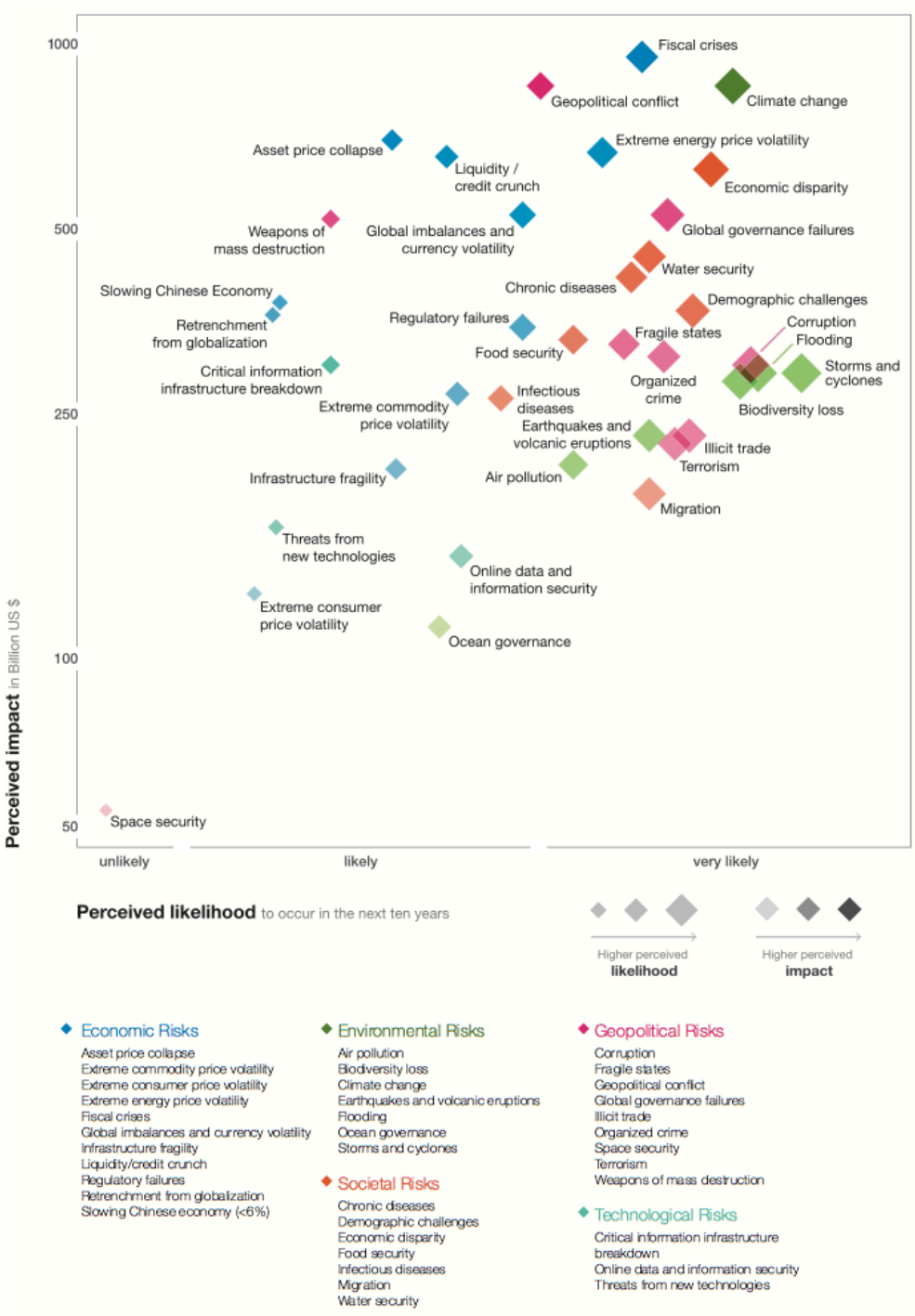
September 1961 –	President Kennedy receives full SIOP-62 briefing
October 1961 –	US and Soviet tanks face off in Berlin
June 1962 –	Operation Anadyr begins transporting Soviet military equipment to Cuba
September 1962	Rachel Carson publishes *Silent Spring*
October 1962 –	Cuban missile crisis
June 1962 –	Washington and Moscow agree to set up direct communications hotline
June 1963 –	Kennedy announces plans for an American SST venture
September 1963 –	US Senate ratifies the Limited Test Ban Treaty
May 1965 –	Scientists prove ozone layer predicated human evolution
November 1970 –	NAS commissions in depth investigation into effects of human activity and ozone depletion
March 1971 –	McDonald testifies to Congress on the link between SST exhaust, ozone depletion, and UV exposure
May 1971 –	Walter Sullivan publishes first major news piece on the risk of ozone depletion
June 1974 –	Sherry Rowland and Mario Molina publish research explaining the link between CFC production and ozone depletion
September 1974 –	Fred C. Iklé explains how nuclear detonations destroy the ozone layer
November 1974 –	NRDC submits petition to ban CFC aerosols
February 1975 –	McElroy testifies on the bromine threat
June 1975 –	IMOS committee releases its conclusion recognizing the likely need to ban aerosols
July 1975 –	Congressional hearings begin on weather modification as a weapon of war
September 1976 –	NAS panel publishes scientific assessment of ozone risk
October 1976 –	FDA announces eventual phase-out
March 1977 –	UNEP hosts first international meeting on protecting the ozone layer
October 1978 –	Federal government begins phase-out of CFC aerosol products
March 1982 –	UNEP forms committee to prepare a convention
March 1985 –	Vienna Convention
May 1985 –	British Antarctic Survey discovers ozone hole
September 1986 –	Du Pont announces support for a global limit on CFC production
September 1987 –	The Montreal Protocol sets global agenda for managing the ozone layer

Figure 2 – Categorizing Existential Risk



Nick Bostrom. "The Concept of Existential Risk." Draft. *University of Oxford.* 2011.

Figure 3 – Risk Perception Today



"Global Risks: 2011, Sixth Edition." *World Economic Forum* (Geneva, January 2011).