"This Awesome Field";

A History of United States Nuclear Testing and its Influence on Nuclear Thought, 1945-1963

A Thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

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Declaration

I certify that except where due acknowledgement has been made, the work is that of the author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the thesis is the result of work which has been carried out since the official commencement date of the approved research program; any editorial work, paid or unpaid, carried out by a third party is acknowledged; and, ethics procedures and guidelines have been followed.

David M. Blades

Preface

When this author was eleven years old, France began a series of nuclear tests at Mururoa Atoll in the South Pacific – to worldwide protest and criticism. I vividly remember the opposition articulated within Australia, and this was my first introduction to the controversy generated by nuclear testing. The French tests between 1995 and 1996 were the last that nation carried out before committing to the Comprehensive Test Ban Treaty, but they showcased how far the norm that governed nuclear weapons testing had shifted since the early Cold War. The conduct of nuclear tests for the purposes of weapons development was not considered an acceptable reason to risk environmental damage and diplomatic opprobrium.

It is within this context that I have sought to construct a history of nuclear testing – albeit a history earlier in time and removed in location – and to reconcile testing with its modern controversy. The thesis that follows was, to borrow the words of Milovan Djilas, "the product of productive forces." Foremost was an interest in nuclear doctrine and strategy that I explored in my undergraduate and Honours years. While reading Richard Rhodes's account of the development of the hydrogen bomb, I became interested in nuclear testing, which Rhodes demonstrated was crucial to the evolution of that weapon. But the kind of operational history of testing that Rhodes touched upon was almost entirely missing from the literature. Nuclear testing is primarily discussed in terms of its radiological effect – upon the environment, and upon populations close to test sites. This otherwise excellent body of work fails to satisfactorily explain the acute importance of nuclear testing to the history of the Cold War.

Similarly, while searching for a topic for my doctoral dissertation, I read the work of Michael Quinlan, who argued that thinking about nuclear weapons and nuclear doctrine was largely speculative because the human experience of nuclear conflict was limited to the bombing of Hiroshima and Nagasaki. But the merciful absence of greater experience with nuclear conflict does not, I argue, render nuclear thought speculative: much knowledge about the use and consequence of nuclear weapons was acquired through their detonation as weapons tests.

This thesis, then, responds to a gap in a literature and refutes the idea that all nuclear thought is based on supposition. Its purpose is to rationalise nuclear testing and present testing as an important component of the wider history of the Cold War. Through testing, nuclear arsenals were refined and perfected, and, as a result of that process, humanity acquired, for the first time in its evolution, the awesome ability to destroy itself.

This thesis adopts an intellectual history of discourse within the Harry S. Truman, Dwight D. Eisenhower and John F. Kennedy Administrations between 1945 and 1963. By presenting a history of the written record of these administrations, I am able to identify the connections between nuclear weapons tests and nuclear thought, and trace the evolution of both. The early history of U.S. testing is valuable not just for its historical perspective on the world's foremost nuclear power, but also for what it tells us about those states in the modern international community who are currently pursuing, or will in the future pursue, a nuclear test program.

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Under other circumstances, the product of doctoral research and the fashioning of a thesis under the guidance of a supervisor would be considered a co-authored document. In that spirit I must first thank Professor Joseph M. Siracusa, with immense gratefulness and admiration, whose wisdom was always accessible and whose enthusiasm was an inspiration. The reader should feel his guiding hand at all points of this thesis.

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I undertook archival research for this thesis at three Presidential Libraries in the United States of America. I wish thank Mr. Randy Sowell of the Harry S. Truman Presidential Library in Independence, Missouri; Mr. Herb Pankratz and Ms. Chalsea Millner of the Dwight D. Eisenhower Presidential Library in Abilene, Kansas; and Mr. Stephen Plotkin and Ms. Stacey Chandler of the John F. Kennedy Presidential Library in Boston, Massachusetts. Their assistance and support were invaluable.

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Whimsical though it might be, at all times while reading on this topic I have felt gratitude to the various historical figures who feature in it – imperfect though they and their actions might have been, the peace they preserved is the one in which I may write and the reader may read about the “awesome field” of nuclear testing.

Table of Contents

Glossary

AEC	Atomic Energy Commission
AICBM	Anti-Intercontinental Ballistic Missile
CIA	Central Intelligence Agency
ERW	Enhanced Radiation Weapon
FCDA	Federal Civil Defense Administration
ICBM	Intercontinental Ballistic Missile
JCAE	Joint Committee on Atomic Energy
JCS	Joint Chiefs of Staff
KT	Kiloton (of TNT equivalent)
LTBT	Limited Test Ban Treaty
MT	Megaton (of TNT equivalent)
NTS	Nevada Test Site
NSC	National Security Council
OCB	Operations Coordinating Board
PPG	Pacific Proving Ground
PSAC	President's Science Advisory Committee
USIA	United States Information Agency

Introduction

This Awesome Field

In March 1954, the United States conducted a series of thermonuclear tests in the Pacific known as Operation CASTLE. Included in this series was CASTLE BRAVO, the largest nuclear test ever carried out by the United States, and also the worst single incident of fallout exposure in the history of the U.S. testing program. Lewis L. Strauss, the chairman of the Atomic Energy Commission, was present and observed these tests; he returned to Washington at the end of the month and made a public statement in response to public fears generated by the BRAVO test. Among his less-than-reassuring comments on nuclear weapons and their testing, Strauss described nuclear testing as "this awesome field."[1]

The field of nuclear testing is indeed an awesome one, in the truest sense of the word. At the most basic level, nuclear tests involved overwhelmingly energetic reactions measured in thousands and millions of tons of conventional explosive equivalent, reactions powered by the same energies that fuel stars. Nuclear weapons tests represented the pinnacle of scientific knowledge, and humanity's ability to manipulate the fundamental structures of the universe. Nuclear fission had been discovered in the year before the outbreak of the Second World War; fission weapons had been developed during the course of the war; and their use at its end seemed to successfully conclude the conflict. Nuclear weapons were thus closely connected to the conclusion of a thoroughly transformative conflict, and their development and

[1] Statement by Lewis L. Straus, Chairman, Atomic Energy Commission, 31 March 1954; Press Conferences Series, Box 2; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

refinement, propelled by the competition of the Cold War, continued in the post-war years. Through nuclear tests, first the United States and then the Soviet Union created deadly arsenals of nuclear weapons and made plans for their use. The threat these arsenals posed was existential not just for the belligerents of a war fought with them, but, eventually, for the species as a whole. Nuclear tests were the most visible, spectacular and awesome demonstration of the power of nuclear weapons, and it is for this reason that nuclear testing was undeniably an "awesome field."

However, this it not to suggest that this thesis is devoted to that awesomeness. The testing of nuclear weapons was also an important aspect of the wider history of the Cold War. The two superpowers that remained standing at the end of the Second World War eyed each other suspiciously over their fallen adversaries, and through nuclear tests they refined their nuclear arsenals. The development of nuclear weaponry and comprehension of their effects was only possible through the test series conducted in the first two decades of the Cold War. Furthermore, test series on occasion assumed political and diplomatic significance wholly divorced from their technical and developmental importance. Nuclear tests were more than a thread of the fabric of the Cold War. They were intimately connected to the crises that punctuated its history, and, together with those crises, were a vivid expression of the contest that the term, Cold War, describes.

Despite their significance, or because of it, nuclear tests have since CASTLE BRAVO in 1954 been associated with radiological contamination, fallout, and their environmental and health effects. Literature that relates specifically to nuclear testing frames it in just this manner, and tends to date from the end of the Cold War.[2] Vital

[2] Wide-focus examples include "Radioactive Heaven and Earth: The Health and Environmental Effects of Nuclear Weapons Testing In, On and Above the Earth," in *International Commission to Investigate the Health and Environmental Effects of*

work has been published on the effect of nuclear testing on indigenous populations and the environment in which tests are conducted: examples include Pieter De Vries' *Mururoa and Us* (1997), Dean Kohlhoff's *Amchitka and the Bomb* (2002) and Alan Parkinson's *Maralinga* (2007).[3] Where test series have been discussed from an operational perspective – such as Jonathan Weisgall's excellent account of the Operation CROSSROADS tests, or Richard Miller's history of testing in Nevada – the inevitable effect that nuclear testing has had upon displaced or exposed populations remains a foremost consideration.[4] With respect and appreciation for this body of work, this thesis nonetheless seeks to discuss nuclear testing separate from these radiological concerns; indeed, it was this emphasis on fallout that helped frame one of this author's basic research questions.

Nuclear testing has more commonly been presented within the context of a more comprehensive examination of a related field. For example, Richard Rhodes's superb *The Making of the Atomic Bomb* (1986) and *Dark Sun: The Making of the*

Nuclear Weapons Production and Institute for Energy and Environmental Research (New York: IPPNW, 1991); Arjun Makhijani, Howard Hu, and Katherine Yih, ed. *Nuclear Wastelands: A Global Guide to Nuclear Weapons Production and its Health and Environmental Effects* (Cambridge: MIT Press, 1995); Philip L. Fradkin, *Fallout: An American Nuclear Tragedy* (Boulder: Big Earth Publishing, 2004); Steven L. Simon and Charles E. Land, "Fallout from Nuclear Weapons Tests and Cancer Risks," *American Scientist* 94, no. 1 (2006).

[3] Pieter De Vries, *Mururoa and Us: Polynesians' Experiences During Thirty Years of Nuclear Testing in the French Pacific* (Lyon: Centre de Documentation et de Recherche sur la Paix et les Conflicts, 1997); Dean Kohlhoff, *Amchitka and the Bomb: Nuclear Testing in Alaska* (Seattle: University of Washington Press, 2002); Alan Parkinson, *Maralinga: Australia's Nuclear Waste Cover-up* (Sydney: ABC Books, 2007). Another example of a narrowed focus on a test series and its radiological effect is E.P. Cronkite, R.A. Conard, and V.P. Bond, "Historical Events Associated with Fallout from Bravo Shot - Operation Castle and 25 Y of Medical Findings," *Health Physics* 73, no. 1 (1997).

[4] Jonathan Weisgall, *Operation Crossroads: The Atomic Tests at Bikini Atoll* (Annapolis: Naval Institute Press, 1994); Richard L. Miller, *Under the Cloud: The Decades of Nuclear Testing* (New York: Free Press, 1986).

Hydrogen Bomb (1995) discuss nuclear test series within the wider history of the atomic and hydrogen bomb and their development.[5] Similarly, David Alan Rosenberg makes fleeting mention of early U.S. test series within a study of the evolution of doctrine for the use of nuclear weapons; while both Robert A. Divine's *Blowing on the Wind* (1978) and Benjamin P. Greene's *Eisenhower, Science Advice, and the Nuclear Test Ban Debate, 1945-1963* (2007) investigate nuclear testing only within their wider discussion of the test ban debate.[6] Missing from the historiography is a comprehensive and dedicated history of nuclear testing and an analysis of its profound consequences on nuclear thought and even the course of the Cold War. The closest example is the work of the late Chuck Hansen. His book *U.S. Nuclear Weapons: The Secret History* (1988) is an exceedingly rare work that, like Rhodes, focuses on testing as it relates to the technical development of nuclear weaponry.[7]

The historiography related to nuclear testing, inadequate as it is, raises important questions about nuclear testing itself. That the notion of testing is typically approached from the perspective of its radiological perils, or a diplomatic agreement to ban tests themselves, speaks to their underlying threat and controversy. Despite this, over 1,900 nuclear tests were conducted by the five declared nuclear powers

[5] Richard Rhodes, *The Making of the Atomic Bomb* (New York: Simon & Schuster, 1986); Richard Rhodes, *Dark Sun: The Making of the Hydrogen Bomb* (New York: Simon & Schuster, 1995). Another example is David Holloway, *Stalin and the Bomb: The Soviet Union and Atomic Energy 1939-1956* (New Haven: Yale University Press, 1994).
[6] David Alan Rosenberg, "The Origins of Overkill: Nuclear Weapons and American Strategy, 1945-1960," *International Security* 7, no. 4 (1983); Robert A. Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960* (New York: Oxford University Press, 1978); Benjamin P. Greene, *Eisenhower, Science Advice, and the Nuclear Test Ban Debate, 1945-1963* (Stanford: Stanford University Press, 2007).
[7] Chuck Hansen, *U.S. Nuclear Weapons: The Secret History* (Arlington, TX: Aerofax, 1988). Rhodes drew upon Hansen's work in his own books, and dedicated *Arsenals of Folly* to Hansen.

between 1945 and 1992.[8] Two questions are posed by this incongruity: firstly, why do states conduct nuclear tests, and, secondly, what can be learned from nuclear tests? As an investment of government authority, nuclear tests have presumably happened for a rational, explainable purpose. At its most basic level, this thesis seeks to reconcile nuclear testing with that rational purpose.

In order to answer these questions, this thesis has adopted a particular focus. A comprehensive study of nuclear testing since 1945 would exceed the constraints of a doctoral dissertation, and such breadth would risk the deserved depth of its analysis. Instead, this examination of nuclear testing is confined to those tests carried out by the United States of America between 1945 and 1963. The United States is the natural focus for such a study because, as Nina Tannenwald writes in her own examination of U.S. non-use of nuclear weapons, the United States

> has seriously considered or threatened the use of nuclear weapons on more occasions than any other nuclear power, it has relied on nuclear weapons most heavily in its defense and alliance policies, it has steadily resisted any specific legal prohibition on first use, and, of course, it is the only country to have actually used nuclear weapons in war.[9]

To these very appropriate reasons to focus on the U.S., this author would append that the United States was the first to test nuclear weapons; remained ahead of all other powers in significant testing milestones; and has conducted more nuclear tests than any other nuclear power. Correspondingly, the thesis is limited in timeframe to those tests conducted between July 1945 and November 1963, at which time the Limited Test Ban Treaty effectively ended atmospheric nuclear testing and drove these experiments underground. This timeframe permits a survey of U.S. atmospheric

[8] This figure averages out to approximately one test every week. "Radioactive Heaven and Earth: The Health and Environmental Effects of Nuclear Weapons Testing In, On and Above the Earth," 159.
[9] Nina Tannenwald, “The Nuclear Taboo: The United States and the Normative Basis of Nuclear Non-Use,” *International Organization*, 53:3 (Summer 1999): 438.

testing and the shift to underground tests, while also offering the viewpoints of three different presidencies on the topic.

In defining the term "nuclear test," this author has adapted the definition used in the Threshold Test Ban Treaty between the United States and Soviet Union, signed in 1974, a definition also used by the Department of Energy.[10] Accordingly, a test is defined as a single nuclear explosion or detonation conducted at a test site for the ostensible function of advancing weapons design, proving theoretical concepts or stockpiled designs, determining weapons effects, and/or for experiments in weapon safety. Nuclear tests differ profoundly from tests of conventional weapons through their sheer scale: this was remarked as early as 1946, when Lee DuBridge, the president of the California Institute of Technology, wrote that "one can do target practice with a gun (even a 16 inch gun) in his own 'backyard' without foreign complications. But brandishing atomic weapons is in a different class."[11] The scale of nuclear tests were such that their effect could be measured beyond national borders.

The history of nuclear testing is an important but sometimes undervalued one. Michael Quinlan argued in his book *Thinking about Nuclear Weapons* that, mercifully, the "evaluation of ideas" regarding nuclear weapons is problematic

[10] The Threshold Test Ban Treaty defines a test as "a single underground nuclear explosion conducted at a test site, or two or more underground nuclear explosions conducted at a test site within an area delineated by a circle having a diameter of two kilometers and conducted within a total period of time of 0.1 second." "Treaty Between The United States of America and The Union of Soviet Socialist Republics on the Limitation of Underground Nuclear Weapon Tests (and Protocol Thereto)," ed. U.S. Department of State (Bureau of Arms Control, Verification and Compliance, 1974). Also, "United States Nuclear Tests: July 1945 through September 1992," (Las Vegas, Nevada: United States Department of Energy, December 2000), xv. The final U.S. test series discussed in this thesis, Operation STORAX, included experiments in simultaneous underground detonations such as those covered by this treaty.

[11] Quoted in Lloyd J. Graybar, "The 1946 Atomic Bomb Tests: Atomic Diplomacy or Bureaucratic Infighting?," *The Journal of American History* 72, no. 4 (1986): 891.

because of a lack of hard evidence; because literature about nuclear war remains speculative; and because historians and analysts must rely upon "concepts, hypotheses and inferences."[12] But Quinlan makes no mention of the evidence provided by nuclear tests, even as he remarks that the "uniquely appalling destructive power" of nuclear weapons is "manifest."[13] This thesis argues that much can be and was learned from nuclear testing, and that the lessons drawn from testing – be they scientific, doctrinal, or political – were rational and compelling reasons to undertake otherwise controversial and contentious test series.[14] Moreover, nuclear testing is not an issue confined to the Cold War of decades past. States continue to test nuclear weapons, or consider that option: North Korea has tested nuclear devices in 2006, 2009 and most recently in 2013, while Iran, should it continue down what appears its current path, will need to test a device in the future to have confidence in its design. Nuclear testing remains an important political issue in the twenty-first century, and the study of its history is vital.

In order to examine the history of U.S. nuclear testing, this thesis will be structured in two parallel dimensions. Firstly, it presents a narrative of U.S. nuclear test series conducted between 1945 and 1963. Secondly, it discusses the ideas

[12] Michael Quinlan, *Thinking About Nuclear Weapons: Principles, Problems, Prospects* (Oxford: Oxford University Press, 2009), 13-14.
[13] Ibid.
[14] The focus of this thesis on overt nuclear testing would seem to exclude Israel, a nuclear state with an ambiguous testing history. Yitzhak Rabin discussed the relationship between testing and introducing weapons when he met with Paul Warnke in 1968 as part of the Johnson Administration's attempt to limit Israeli strategic weapons. Israel argued, playing to its strategy of an indistinct nuclear threat, that "throughout the world, experience indicated that the introduction of a weapon could only occur after testing. You could not introduce a weapon until after it actually became a weapon." Rabin asked Warnke "Do you consider a nuclear weapon one that has not been tested, and has been done by a country without previous experience?" Michael Karpin, *The Bomb in the Basement: How Israel Went Nuclear And What That Means For The World* (New York: Simon & Schuster, 2006), 300, 310.

generated by these test series. Both dimensions, but particularly the latter, use an intellectual history to analyse the thoughts prevalent within the White House as U.S. nuclear testing evolved. This thesis uses the documents of three presidential administrations – that of Harry S. Truman (1945-1953), Dwight D. Eisenhower (1953-1961) and John F. Kennedy (1961-1963) – as the basis of this intellectual history, because this author argues that the ideas discussed within the White House offer a more comprehensive understanding of nuclear testing than those more focused discussions that undoubtedly occurred within the Atomic Energy Commission or the Department of Defense. It was the sheer scale and consequence of nuclear weapons and their testing that made those weapons more the purview of civilian government than any other weapons system. Chapters One, Three and Five provide the history of U.S. nuclear testing under the presidencies of Truman, Eisenhower and Kennedy, respectively. Chapters Two, Four and Six are thematic examinations of the evolution of nuclear thought as it was influenced by nuclear testing. Chapter Two considers the normalisation of nuclear testing, together with the paradigm of weapons design.[15] Chapter Four discusses the expansion of nuclear testing under Eisenhower, along with the important elements of its suspension. Chapter Six considers the political dimensions to nuclear testing and the manner in which the test series held under Kennedy affected the negotiations for the Limited Test Ban Treaty. These chapters shall demonstrate that the testing of nuclear weapons was a rational state act, from which much of our knowledge about nuclear weapons and their consequence derives.

[15] It should be noted that, of the libraries accessed by the author, there was a comparative paucity of material within the Harry S. Truman Library related to nuclear testing. The second chapter of this thesis thus makes greater use of secondary sources than Chapters Four and Six.

Chapter One

Truman, 1945-1952

"We are fully conscious that our real goal is still before us. The battle test is what counts in the war with Japan."

Letter to Henry Stimson from General Leslie Groves following the Trinity test, 18 July 1945.

"The Survey has estimated that the damage and casualties caused at Hiroshima by the one atomic bomb dropped from a single plane would have required 220 B-29s carrying 1,200 tons of incendiary bombs, 400 tons of high-explosive bombs, and 500 tons of anti-personnel fragmentation bombs, if conventional weapons, rather than an atomic bomb, had been used."

United States Strategic Bombing Survey: Summary Report (Pacific War),
1 July 1946.

The greatest war in human history in both cost and consequence ended with the use of atomic weapons. These weapons represented a qualitative revolution in technology and firepower; they had been developed and produced through the years of the Second World War, and represented the forefront of scientific knowledge. But as the peace of the post-war world turned into Cold War, the weapons whose use had concluded the Second World War were refined and further developed through nuclear testing. Under the presidency of Harry S. Truman, the goal of these tests was weapons development. Excluding the attacks on Hiroshima and Nagasaki, a total of thirty nuclear tests were conducted by the United States between July 1945 and October 1952. These thirty tests were held as six test series, in addition to the wartime

TRINITY test. Of these thirty shots, the Department of Energy classifies twenty-four as “weapons related” tests, meaning that eighty per cent of the nuclear tests conducted by the United States during this period were done so for the purpose of furthering development of nuclear weapons design.[1]

The nuclear tests conducted during these years took place in the context of worsening relations with the Soviet Union and the decline of post-war international relations into Cold War. These developments in turn saw, firstly, the end of the United States’ atomic monopoly and the victory of communist China over nationalist China in the Chinese Civil War in 1949, and secondly, the United States’ involvement in the Korean War from 1950 onwards, fighting first against North Korea and then also China. The first Soviet atomic test in August 1949 and the war in Korea in June 1950 would affect the United States’ test program; the former led to internal debate within the Truman Administration of the merits of developing thermonuclear weapons, culminating in Truman’s directive of 31 January 1950 to do just that, while the latter created operational and logistical challenges to testing in the Pacific.

Almost from the outset of the atomic age, it was recognised that atomic weapons should be controlled and their testing limited. This recognition was best seen in the Acheson-Lilienthal Report, which in turn led to the Baruch Plan, submitted to the United Nations in 1946. It was with the Soviet rejection of this proposal that the United States nuclear test program began its generally upward trend, as seen in Appendix One, which shows a broad increase in number of shots per series and/or in the total yield of series. This graph does not show the expansion of testing facilities in the Pacific and the continental United States.

[1] "United States Nuclear Tests: July 1945 through September 1992," 2-5.

No single structural cause for this acceleration can be easily identified; it was likely a confluence of the expansion of the atomic stockpile (requiring testing of new designs and permitting quantitatively more weapons to be tested), the decision to develop the thermonuclear bomb, and the exigencies of the Korean War. These are issues discussed in more depth in Chapter Two.

This chapter will explore the nuclear tests conducted by the United States between 1945 and 1952, during the period in which it tested fission weapons. It will examine the six test series – CROSSROADS, SANDSTONE, RANGER, GREENHOUSE, BUSTER-JANGLE and TUMBLER-SNAPPER – together with the wartime TRINITY and Hiroshima explosions. This history will provide greater context for the deeper analysis of Chapter Two. This chapter shows that, although each of the series was important, none was more so than SANDSTONE and GREENHOUSE, especially given the focus on weapons design prevalent during this period.

TRINITY

The first test of a nuclear device was conducted in New Mexico on 16 July 1945. A press release relating to this test dramatically described the event in terms of "[m]ankind's successful transition to a new age, the Atomic Age."[2] The TRINITY test was indeed a point of transition, but it also marked the successful culmination of many years of secret, scientific effort toward a speculative goal. This effort has been

[2] War Department Release as Background Information on the July 16 Test; Atomic Bomb: Alsop Article to Atomic Bomb: Press Releases [3 of 3]; Box 174; National Security Council – Atomic File; PSF: Subject File 1940-1953; Truman Papers, Truman Library.

extensively documented in other works.[3] It is sufficient to note, as did the press release of the War Department in July 1945, that the implosion of this “small amount of matter” was “the product of a chain of huge and specially constructed industrial plants,” and that, for the first time, the TRINITY test had released “the energy of the universe locked up within the atom from the beginning of time.”[4]

The TRINITY shot was a test of a plutonium, implosion-type device. It was detonated in the desert south-east of Socorro, New Mexico, in the pre-dawn darkness at 0530 on 16 July 1945.[5] Initial estimates of energy generated by the explosion were “in excess of the equivalent of 15,000 to 20,000 tons of TNT;”[6] the U.S. Department of Energy now specifically reports the yield as 21 kilotons.[7] The device was emplaced on a 100-foot (30-metre) steel tower. Interestingly, General Leslie R. Groves, director of the Manhattan Project, found it necessary to highlight in a memo to secretary of

[3] For an account of the Manhattan Project and the TRINITY test, see Richard Rhodes, *The Making of the Atomic Bomb* (New York: Simon & Schuster, 1986). See also Cynthia C. Kelly, ed., *The Manhattan Project: The Birth of the Atomic Bomb in the Words of Its Creators, Eyewitnesses, and Historians* (New York: Black Dog & Leventhal Publishers, 2007), and Joseph M. Siracusa, *Nuclear Weapons: A Very Short Introduction* (Oxford: Oxford University Press, 2008), 10-27.

[4] War Department Release; Atomic Bomb: Alsop Article to Atomic Bomb: Press Releases [3 of 3]; Box 174; National Security Council – Atomic File; PSF: Subject File 1940-1953; Truman Papers, Truman Library.

[5] The TRINITY blast was preceded on 7 May 1945 by a conventional explosive test in which 100 tons of high explosive, seeded with tubes of radioactive material, was detonated from a test tower. This pre-shot experiment gave Manhattan Project personnel experience with the forthcoming atomic test, and calibrated instruments for the detection of yield and radiation. Carl Maag, et al., "Project TRINITY, 1945-1946," in *United States Atmospheric Nuclear Weapons Tests Nuclear Test Personnel Review* (Washington, D.C.: Defense Nuclear Agency, 1982), 23-26. See also, K.T. Bainbridge, et al., "Trinity," (Los Alamos, New Mexico: Los Alamos Scientific Laboratory of the University of California, 1976), 7-14.

[6] Memorandum for the Secretary of War, 18 July 1945; The Decision to Drop the Atomic Bomb on Japan, #4; Box 1 of 1; Student Research File; Truman Library.

[7] "United States Nuclear Tests: July 1945 through September 1992," 2-3.

war Henry Stimson, dated two days after the test, that the device had been installed upon this tower and had not been dropped from an airplane.[8]

The flash of the detonation was visible in the cities of New Mexico – Albuquerque, Santa Fe, Silver City – and El Paso, in northern Texas, but generally to a distance of 180 miles (290 kilometres). At the instant of its detonation the flash of TRINITY was brighter than any light ever produced on Earth, and was visible from another planet.[9] The sound of the explosion was heard within a 100-mile (160-kilometre) radius. Within a radius of 20 miles (32 kilometres), "there was a lighting effect…equal to several suns in midday; a huge ball of fire formed which lasted for several seconds."[10] From this fireball the mushroom cloud formed, which surged upward through a temperature inversion at 17,000 feet (5.2 kilometres) that many scientists predicted would suppress the updraft, and reached the substratosphere at 41,000 feet (12.5 kilometres) within five minutes. The mushroom cloud lifted thousands of tons of dust from the New Mexico desert, and fissionable material and other radioactive products mixed with this dust. Varying winds dispersed the column of radioactive dust, and radioactive fallout was for the first time deposited "over a wide area."[11]

In his memorandum to Stimson, General Groves made a number of interesting observations about the effects of the atomic bomb. These observations give to their reader a sense of the power of the TRINITY test more clearly than any recital of the size of the resulting crater, or the effect upon nearby structures. Firstly, Groves reported that he could "no longer consider the Pentagon a safe shelter from such a

[8] Memorandum for the Secretary of War, 18 July 1945; The Decision to Drop the Atomic Bomb on Japan #4; Box 1 of 1; Student Research File; Truman Library.
[9] Siracusa, *Nuclear Weapons: A Very Short Introduction*: 20.
[10] Ibid.
[11] Ibid.

bomb."[12] This consideration is particularly telling when one also considers that Groves directed the construction of the Pentagon prior to assuming responsibility for the Manhattan Project. Secondly, Groves noted that although he found "no reason to anticipate" the loss of the bomber that would deliver such a bomb to its target, he could neither assure nor guarantee the safety of the delivery plane "in an actual operation."[13] Groves was unable to do so because the thunderstorms that jeopardised the shot time and which feature in the recollections of many witnesses of TRINITY also prevented observation bombers from approaching the detonation at prescribed distances.

TRINITY proved many things. To start with, it proved the implosion-type design, whereby the force of the detonation of high-explosive lenses would compress and concentrate a subcritical core of plutonium into a supercritical mass, a design that was used to effect above Nagasaki only weeks later. But it also proved the possibility of a notion that had remained until that point purely theoretical. In the words of the War Department's press release: "[s]peculative theory, barely established in pre-war laboratories, had been projected into practicality."[14] This projection of speculative theory into practicality would prove as important a catalyst to the Soviet atomic program as its spectacular use against Japan in the coming weeks.[15]

With some degree of foreboding, Groves concluded his memorandum to Stimson with the following: "[w]e are fully conscious that…the battle test is what

[12] Ibid.
[13] Ibid.
[14] War Department Release; Atomic Bomb: Alsop Article to Atomic Bomb: Press Releases [3 of 3]; Box 174; National Security Council – Atomic File; PSF: Subject File 1940-1953; Truman Papers, Truman Library.
[15] For an account of the beginnings of the Soviet atomic program, see David Holloway, *Stalin and the Bomb: The Soviet Union and Atomic Energy 1939-1956* (New Haven: Yale University Press, 1994).

counts in the war with Japan."[16] With the implosion-assembly device tested and proven by TRINITY, the gun-assembly device would be tested above Hiroshima.

Little Boy

The detonation of the gun-assembly Little Boy device above Hiroshima on 6 August 1945 has not been considered by the historiography as a nuclear test.[17] The Department of Energy explicitly rejected the notion that the two wartime uses of atomic bombs could be considered tests: "these detonations were not 'tests' in the sense that they were conducted to prove that the weapon would work as designed…or to determine weapons effects..."[18] However, Little Boy was an untested design, and its successful detonation above Hiroshima proved that design in a manner not dissimilar to that by which TRINITY proved the Fat Man design; moreover, the United States derived much information regarding weapons effects from both Hiroshima and Nagasaki, as evidenced by the extensive Strategic Bombing Surveys.[19]

The definition as articulated by the Department of Energy suggests an intent behind a nuclear event that determines whether an event is a nuclear test. This is

[16] Memorandum for the Secretary of War, 18 July 1945; The Decision to Drop the Atomic Bomb on Japan #4; Box 1 of 1; Student Research File; Truman Library.

[17] Much of the recent literature regarding Hiroshima is related instead to debate of the decision to drop the atomic bomb. For a good review of this discourse, see the beginning of chapter six of Wilson D. Miscamble, *From Roosevelt to Truman: Potsdam, Hiroshima, and the Cold War* (New York: Cambridge, 2007), 218-220.

[18] Department of Energy, "United States Nuclear Tests: July 1945 through September 1992," vii.

[19] For these weapons effects, see U.S. Strategic Bombing Survey: The Effects of the Atomic Bombings of Hiroshima and Nagasaki, 19 June, 1946; President's Secretary's File; Truman Papers. For an account of the conventional bombing of Japan that preceded the atomic bombings, see United States Strategic Bombing Survey: Summary Report (Pacific War), 1 July 1946; President's Secretary's File; Truman Papers. Both documents have been digitised and are available among the Online Documents at the website of the Harry S. Truman Presidential Library.

certainly appropriate. This author does not wish to suggest that the significance of the deaths of 66,000 people at Hiroshima should be lessened by defining that event as a weapons test.[20] The circumstances in which Little Boy was detonated, and the effect that detonation had upon human population, raise natural and moral objections to its classification as anything but a tragedy of war. But it should not be denied that, in many senses, including those rejected by the Department of Energy, the wartime use of the Little Boy device might qualify as a nuclear test. From a purely technical perspective, divorced entirely from the moral consideration of its use, Little Boy should be seen as a weapons design proof test.[21]

The attack on Hiroshima was reported to Truman by Stimson in terms relative to TRINITY. In a cable to the president, Stimson wrote that "first reports indicate complete success which was even more conspicuous than earlier test."[22] The conspicuousness of Little Boy was related to the place of its detonation – above a city – rather than its yield: Little Boy yielded 14 kilotons, rather than the 21 kilotons of TRINITY. "Results clear cut successful in all respects," read one subsequent report, "[v]isible effects greater than any test. Conditions normal in airplane following delivery."[23]

[20] This figure from Lawrence Freedman, *The Evolution of Nuclear Strategy*, Third Edition ed. (New York: Palgrave Macmillan, 2003), xiii. Tens of thousands more died as a result of radiation sickness in the aftermath.

[21] Jozef Goldblat and David Cox argued that "the use of the bomb was in itself a test" when interrogating the necessity to test an atomic weapon before building a stockpile. Jozef Goldblat and David Cox (eds.), *Nuclear Weapons Tests: Prohibition or Limitation?* (New York: Oxford University Press, 1988), 4.

[22] The Secretary of War to the President, 6 August 1945; Atomic Bomb: Alsop Article to Atomic Bomb: Press Releases [3 of 3]; Box 174; NSC – Atomic File; PSF: Subject File 1940-1953; Truman Papers, Truman Library.

[23] Admiral Edwards to Admiral Leahy, 6 August 1945; Atomic Bomb: Alsop Article to Atomic Bomb: Press Releases [3 of 3]; Box 174; National Security Council – Atomic File; PSF: Subject File 1940-1953; Truman Papers, Truman Library.

If the detonation of Little Boy proved the success of the uranium, gun-assembly device – a design that would become prevalent in the atomic artillery of the 1950s – then the conditions aboard the *Enola Gay* following delivery proved by example the method of delivery. This dimension of the bombing of Hiroshima is commonly accepted but should not be taken for granted; recall that after TRINITY General Groves expressed caution toward the survivability of the delivery bomber in the aftermath of an atomic explosion. The report "conditions normal in airplane following delivery" confirmed a pre-existing assumption that the United States' strength in strategic bombing could be easily adapted to delivering atomic bombs.

If one measurement simultaneously communicates both the scale of damage inflicted upon Hiroshima and the importance of this new weapon to U.S. strategic bombing, it might be that reported by the post-war Strategic Bombing Survey:

> The Survey has estimated that the damage and casualties caused at Hiroshima by the one atomic bomb dropped from a single plane would have required 220 B-29s carrying 1,200 tons of incendiary bombs, 400 tons of high-explosive bombs, and 500 tons of anti-personnel fragmentation bombs, if conventional weapons, rather than an atomic bomb, had been used…This estimate pre-supposed bombing under conditions similar to those existing when the atomic bombs were dropped and bombing accuracy equal to the average attained…during the last 3 months of the war.[24]

This was, of course, an optimistic estimate – it would be irresponsible to assume the kind of total aerial supremacy that the United States enjoyed above Japan at the end of the war, just as it would be to expect the kind of experience and veterancy of its air crew that the bomb group responsible for Hiroshima and Nagasaki had developed in the strategic campaign against Japan. The above estimate is a useful one nonetheless, as it gives a rough conversion rate, for lack of a better term, between atomic and conventional bombing at the beginning of the atomic age.

[24] United States Strategic Bombing Survey: Summary Report (Pacific War), 1 July 1946; President's Secretary's File; Truman Papers.

Little Boy poses a challenge to the argument that testing is crucial to the development of nuclear weapons, because Little Boy was itself an untested design when used against Hiroshima. The fact that the gun-assembly Little Boy device was not tested before its use, while the implosion-assembly Fat Man device was, might suggest that only the least-robust of designs or theories need be tested, or that there is a lesser need to confirm theoretical developments through full-scale testing. While there is some merit to this line of thought – here one thinks of Oppenheimer's arguments against the 1946 tests series, which I shall soon explore – it cannot be applied to Little Boy. Little Boy used all sixty-four kilograms of uranium-235 that the United States had accumulated and enriched before July 1945; there was not enough of this superdense material left to test another device.[25] As a result, Little Boy was an "extremely conservative design," divested of safety features so as to increase its reliability.[26] Little Boy was a product of the pressures of war in every sense.

Nowhere was it written that nuclear testing would continue after the end of the Second World War, although in hindsight it seems a natural progression. The assumption that atomic bombs could be tested and improved in the same manner as conventional weapons relies upon the assumption that nuclear weapons are not qualitatively different from conventional weapons. The debate in this regard is extensive and largely beyond the scope of this thesis, but the debate itself emerged in the period leading up to the first peacetime nuclear test series, Operation CROSSROADS.[27]

[25] Rhodes, *Dark Sun: The Making of the Hydrogen Bomb*: 17.
[26] Ibid.
[27] In addressing the CROSSROADS tests, Graybar connects this assumption with concerns about international relations. Graybar, "The 1946 Atomic Bomb Tests: Atomic Diplomacy or Bureaucratic Infighting?"

CROSSROADS

The Operation CROSSROADS tests were conducted in 1946, when, as Lloyd Graybar eloquently framed it, "the contours of the Cold War were becoming sharply defined," and were the first nuclear tests conducted during peacetime – and, thus, without the secrecy that surrounded TRINITY.[28] CROSSROADS consisted of two shots (with a third shot planned but cancelled) and was conducted at Bikini Atoll in the Marshall Islands. These shots were the first detonations of atomic weapons since the wartime use against Japan, and the fourth and fifth nuclear events of history.[29]

Brien McMahon, chairman of the Special Senate Committee on Atomic Energy, wrote to Truman regarding the tests and noted that the designation of "CROSSROADS" was "most appropriately chosen" by the Navy because it communicated the great importance of the tests to the American people.[30] Of the goal of the tests, McMahon was "convinced that these tests were being planned and will be executed to demonstrate fairly and conclusively the value of present-type Naval vessels."[31] But McMahon was writing tendentiously. The stated purpose of the CROSSROADS tests was indeed to determine the effect of the atomic bomb upon

[28] Ibid., 890.
[29] For an excellent account of CROSSROADS within the context of the Cold War, see the aforementioned article by Graybar. For an in-depth account of the entirety of Operation CROSSROADS, see Jonathan Weisgall, *Operation Crossroads: The Atomic Tests at Bikini Atoll* (Annapolis: Naval Institute Press, 1994).
[30] Senator Brien McMahon to President Harry Truman, 6 February 1946; Atomic Energy: President's Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Truman Papers, Truman Library. Brien McMahon served as Democratic Senator from Connecticut from 1945 through to his death from cancer in 1952. He authored the McMahon Act, which became the Atomic Energy Act of 1946, establishing civilian control of nuclear weapons through the Atomic Energy Commission. In addition to the Special Senate Committee on Atomic Energy, McMahon also chaired its successor, the Joint Congressional Committee on Atomic Energy in 1946 and again in 1949-1952.
[31] Ibid.

naval vessels, but with the specific intent to identify the need for changes in ship design, formations at sea and anchoring distances in port, number and location of bases, and the strategic disposition of ships.[32] Secondary purposes of the tests included the determination of weapons effects upon aircraft and military ground weapons and equipment; effects upon living beings; and to "gain information regarding the relative value of atomic bomb attack against naval vessels, as compared with other types of targets."[33] Not among those purposes was the intent to validate contemporary naval designs.

CROSSROADS was, then, the first weapons effects test series, and the Department of Energy today classifies the shots that composed the series as such.[34] CROSSROADS permitted the first close study of weapons effects in a controlled environment, and, in the absence of the wartime secrecy of TRINITY, the CROSSROADS shots were much more accurately measured and observed. These tests were described in memoranda as "in the nature of a laboratory experiment," and the close study of weapons effects was to furnish designers of weapons platforms and strategists important information about a "revolutionary new weapon."[35] Each of the three planned tests produced two or more types of weapons effects, studied according to the purposes outlined above.[36]

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[32] Purposes of Atomic Bomb Tests and Reasons for Conducting Them at an Early Date, 2 April 1946; Atomic Energy: President's Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Truman Papers, Truman Library.
[33] Ibid.
[34] "United States Nuclear Tests: July 1945 through September 1992," 2-3.
[35] Secretary of War and Secretary of the Navy to the President, 6 April 1946; 692 Misc. Civilian Control of Atomic Energy (x) – 692 A Misc. (1945), Box 1527; Official File; Truman Papers, Truman Library.
[36] Purposes of Atomic Bomb Tests and Reasons for Conducting Them at an Early Date, 2 April 1946; Atomic Energy: President's Directive [1 of 3] to Atomic

The relative absence of the secrecy that surrounded TRINITY, and the manner in which the world was forewarned about the CROSSROADS tests, permitted loud voices to be raised in objection to the series. This objection was manifested not only as an internal discourse within the Truman Administration: CROSSROADS was the first example of public opposition to atmospheric nuclear testing. Public opposition was strongest in March through to May, and, in April, Truman issued a statement in which he articulated his "complete agreement with the Joint Chiefs of Staff and the Secretary of War and the Navy in their view that these tests are of vital importance in obtaining information for the national defense."[37]

J. Robert Oppenheimer, the scientific director of the Manhattan Project, articulated many of the arguments against the CROSSROADS tests in his letter to Truman of May.[38] In that letter, Oppenheimer argued for model tests and calculations, being less costly than full-scale nuclear tests and possibly more useful; he noted that there was a possibility of the devices giving an ineffective explosion, a fizzle, that would underwhelm observers and threaten the image of American atomic power; and he observed the dissonance between the conduct of "a purely military test of atomic weapons" at a time when the Acheson-Lilienthal Report on the control of atomic

Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Truman Papers, Truman Library.

[37] Statement by the President, 12 April 1946; 692 Misc. Civilian Control of Atomic Energy (x) – 692 A Misc. (1945), Box 1527; Official File; Truman Papers, Truman Library.

[38] A comprehensive and recent biography of the fascinating life of Oppenheimer can be found in Ray Monk, *Inside the Centre: The Life of J. Robert Oppenheimer* (London: Random House, 2013). For a compilation of primary material related to the hearing that revoked Oppenheimer's security clearance in 1954, see Richard Polenberg (ed.), *In the Matter of J. Robert Oppenheimer: The Security Clearance Hearing* (Ithaca: Cornell University Press, 2002).

energy was to be submitted, as the Baruch Plan, to the United Nations.[39] Moreover, Oppenheimer noted that naval applications of the atomic bomb were "not important ones to test," and nor were the tests a "good measure of naval applications."[40] It was in forwarding Oppenheimer's letter to Dean Acheson that Truman famously labelled Oppenheimer a "cry baby."[41]

A criticism not made by Oppenheimer but which featured in the internal discourse of the administration was that CROSSROADS was to be "conducted in a prejudiced way to further Navy interests."[42] This criticism was perhaps a natural result of the test series being run by the Navy – let us not forget that CROSSROADS predated the Atomic Energy Act and the formation of the Atomic Energy Commission (AEC). The reproach by the secretary of commerce that the test series was "prejudiced" was accompanied by the suggestion that the president appoint a civilian oversight board, which eventually manifested as the Evaluation Commission chaired by Senator Carl Hatch (D-NM).

Public sentiment echoed at least one of Oppenheimer's arguments – that there was a threatening gesture contained within the CROSSROADS tests. The proposed shots were described as "a vulgar display of fiendish strength…to encourage other

[39] J.R. Oppenheimer to President Truman, 3 May 1946; Atomic Energy: President's Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Truman Papers, Truman Library.

[40] Ibid.

[41] The President to the Acting Secretary of State, 7 May 1946; Atomic Energy: President's Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Truman Papers, Truman Library.

[42] Naval Atomic Bomb Tests, H.A. Wallace to President Truman, 6 February 1946; Atomic Energy: President's Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Truman Papers, Truman Library. See also Graybar, "The 1946 Atomic Bomb Tests: Atomic Diplomacy or Bureaucratic Infighting?," 891-95.

countries to work more militarily at the perfection of weapons";[43] likewise, one citizen suggested military tests were not in accord with the "expressed intention" of the Truman Administration that atomic weapons be controlled;[44] while another citizen wrote that whatever information learned from the series would be meaningless if the atomic bomb came to be eliminated from national arsenals.[45]

Much of the public opposition to the tests was related to a lack of understanding of atomic weapons, which of itself was probably a natural feature of the early years of the so-called "Atomic Age."[46] For example, concerns were raised that the shots would generate widespread tsunamis, or cause famine through the poisoning of "millions of tons of fish and other sea-food."[47] The State Department even received a request from a Cuban national to remain aboard the target ships so that he could "contribute detailed information on the exact behaviour of atomic explosions and their effects on the human body."[48]

[43] Elizabeth T. Johnson to President Truman, 13 March 1946; 692 A Misc. (1946) – 692 A Reaction to Russian A-bomb, Box 1528; Official File; Truman Papers, Truman Library.
[44] Richard Sill to President Truman, 13 March 1946; 692 A Misc. (1946) – 692 A Reaction to Russian A-bomb, Box 1528; Official File; Truman Papers, Truman Library.
[45] Clark M. Eichelberger to President Truman, 23 March 1946; 692 A Misc. (1946) – 692 A Reaction to Russian A-bomb, Box 1528; Official File; Truman Papers, Truman Library. To this last letter, Truman's reply of 29 March is available – it thanks Mr. Eichelberger for his letter and said only "I am glad to have your views on it."
[46] For a good account of these concerns, see chapter seven of Weisgall, *Operation Crossroads: The Atomic Tests at Bikini Atoll.*
[47] Mrs. M. Conan to President Truman, 3 April 1946; 692 A Misc. (1946) – 692 A Reaction to Russian A-bomb, Box 1528; Official File; Truman Papers, Truman Library.
[48] F.G. López Pérez to the President, 4 July 1946; 692 A Misc. (1946) – 692 A Reaction to Russian A-bomb, Box 1528; Official File; Truman Papers, Truman Library.

Perhaps the most harrowing anecdote related to lack of understanding of atomic bombs comes from Bill, a sailor aboard *USS PGM-32*, a small motor gunboat that was assigned to support CROSSROADS. Bill wrote to his family a solemn letter in which he bid farewell, because, although noting that his gunboat was to be "30 minutes from the explosion when the bomb goes off," Bill was convinced that "there is not much chance for us" and that "we will not come back."[49] *PGM-32* was to be stationed 21 miles (38 kilometres) upwind of the point of detonation.[50] Bill concluded his letter by questioning "why they send us out there when they know we will all get killed, but they said they expected to lose six or seven hundred men."[51] Researchers have access to this letter because Bill's family relayed it to their congressman, who in turn relayed it to the White House, where it was passed on to the commander of CROSSROADS, Vice Admiral Blandy. Congressman Clifford Davis (D-TN) noted that, although the "distressing" letter was likely "the writing of a homesick boy," were its contents made public, "some fellow who doesn't like us could make a lot of talk out of this."[52] Vice Admiral Blandy reassured all involved that "the fears expressed by the sailor on that ship are without foundation."[53]

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[49] Bill to Mom, Dad and All, 15 March 1946; 692 Misc. Civilian Control of Atomic Energy (X) – 692 A Misc. (1945), Box 1527; Official File; Truman Papers, Truman Library.

[50] Vice Admiral W.H.P. Blandy to the Naval Aide to the President, 9 April 1946; 692 Misc. Civilian Control of Atomic Energy (X) – 692 A Misc. (1945), Box 1527; Official File; Truman Papers, Truman Library.

[51] Bill to Mom, Dad and All, 15 March 1946; 692 Misc. Civilian Control of Atomic Energy (X) – 692 A Misc. (1945), Box 1527; Official File; Truman Papers, Truman Library.

[52] Congressman Cliff Davis to Matthew J. Connelly, 29 March 1946; 692 Misc. Civilian Control of Atomic Energy (X) – 692 A Misc. (1945), Box 1527; Official File; Truman Papers, Truman Library.

[53] Captain Clark M. Clifford to Matthew J. Connelly, 10 April 1946; 692 Misc. Civilian Control of Atomic Energy (X) – 692 A Misc. (1945), Box 1527; Official File; Truman Papers, Truman Library.

Shots ABLE and BAKER were each successful. Each was of the same design as those used at TRINITY and Nagasaki (that is, a plutonium, implosion-type device) and both yielded 21 kilotons.[54] Concentrated in the lagoon were some ninety target warships – some captured from the defeated Japanese and German navies, together with many obsolete American ships – that were arranged so as to give technical information on the atomic explosions, rather than to simulate a battle formation.[55] CROSSROADS ABLE was an airburst, dropped by a B-29 bomber; Senator Hatch reported to Truman the dramatic sinking of destroyers, cruisers and transport ships.[56] Hatch was writing in the enthusiasm of the moment, for the destructive effect of ABLE was less than anticipated. Indeed, two Soviet observers (present for the shots because the United States had invited to observe the tests members of the U.N. Commission to which Baruch had presented his plan for international control of atomic weapons two weeks earlier) reported "general disappointment with the results of the explosion" and that, because the target ships had survived reasonably well, the "material results of the explosion proved to be insignificant compared with what had been expected here."[57] The underwhelming results were mainly due to inaccurate delivery of the ABLE device, which missed the target, *USS Nevada*, by 2,130 feet (650 metres).[58]

[54] "United States Nuclear Tests: July 1945 through September 1992," 2-3.
[55] Carl A. Hatch to President Truman, 4 July 1946; Atomic Energy: President's Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Truman Papers, Truman Library.
[56] Ibid.
[57] Holloway, *Stalin and the Bomb*, 163, 227.
[58] James P. Delgado, et al, "The Archaeology of the Atomic Bomb: A Submerged Cultural Resources Assessment of the Sunken Fleet of Operation Crossroads at Bikini and Kwajalein Atoll Lagoons," (Sante Fe, New Mexico: United States Department of the Interior, 1991), 24.

BAKER was by comparison much more effective. The second shot was reported to Truman as "in some respects…of even greater interest [than ABLE], for it will have no precedent."[59] BAKER detonated underwater, and the water transferred the effect of the bomb blast to target ships more effectively than the atmosphere. Images of the blast suggested that the *USS Arkansas*, a 26,000-ton battleship, was immediately upended by the blast and sunk thereafter.[60] The BAKER shot sank two battleships and an aircraft carrier, and many other destroyers, submarines and auxiliaries.[61] The underwater detonation lifted some ten million tons of irradiated seawater into a column that fell back down upon the target ships. The target ships were so irradiated that boarding parties could not approach them for at least four days.[62]

Decontamination efforts in the wake of the underwater BAKER shot were focused upon the ships designated for use in CROSSROADS CHARLIE.[63] On 30 August, Robert P. Patterson, the secretary of war, and James Forrestal, the secretary of the navy, wrote to Truman to advise that neither they nor the Joint Chiefs of Staff (JCS) any longer considered the third CHARLIE shot to be necessary. This memorandum couched their advice in terms that ABLE and BAKER had "retarded" the "research and development progress of the Manhattan Project" through the

[59] Carl A. Hatch to President Truman, 4 July 1946; Atomic Energy: President's Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Truman Papers, Truman Library.
[60] Preliminary Report Following the Second Atomic Bomb Test, 2 August 1946; 692 Misc. Civilian Control of Atomic Energy (X) – 692 A Misc. (1945), Box 1527; Official File; Truman Papers, Truman Library.
[61] Delgado, "The Archaeology of the Atomic Bomb," 28.
[62] Preliminary Report Following the Second Atomic Bomb Test, 2 August 1946; 692 Misc. Civilian Control of Atomic Energy (X) – 692 A Misc. (1945), Box 1527; Official File; Truman Papers, Truman Library.
[63] Delgado, "The Archaeology of the Atomic Bomb," 30.

absence of scientists from theoretical work, and that CHARLIE would exacerbate this effect.[64] Furthermore, they wrote, the "additional information expected from Test 'C' does not warrant the expenditure in money, manpower, and effort involved."[65] However, recent scholarship suggests that among the reasons for the cancellation of CHARLIE was the serious irradiation of the designated target ships by BAKER, and the inability of the Navy to successfully decontaminate these vessels.[66] Truman replied to Forrestal with his decision to "indefinitely postpone" CHARLIE on 7 September.[67] The effects to be tested in shot CHARLIE, a deep underwater nuclear explosion, were not observed until Operation WIGWAM in 1955.[68]

As the first atmospheric tests of nuclear weapons since their wartime use, the two shots of Operation CROSSROADS set a number of precedents for subsequent test series. Foremost was that atomic weapons could and should be tested in circumstances distinct from TRINITY (that is, without the sole intent to prove their function) – even while simultaneous efforts were being made in the international forum to control atomic energy. Another precedent was that the United States would test these weapons in the atmosphere, and, to do so far from its population centres, the

[64] Patterson and Forrestal to President Truman, 30 August 1945 [sic]; Atomic Energy: President's Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Truman Papers, Truman Library. This memorandum was, presumably, misdated "30 August 1945" as CROSSROADS was held in 1946 and the announcement of the cancellation was made in early September 1946.
[65] Ibid.
[66] For an account of decontamination efforts following CROSSROADS BAKER, see chapter two of Delgado, "The Archaeology of the Atomic Bomb," 27-31.
[67] President Truman to the Secretary of the Navy, 7 September 1946; Atomic Energy: President's Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Truman Papers, Truman Library.
[68] See Chapter Three.

United States would test in its Trust Territory overseas.[69] Connected to this, CROSSROADS saw the earliest concern about the environmental and radiological consequences of nuclear testing. Finally, from the beginning of the test program – long before accidents like that which befell the *Lucky Dragon* during Operation CASTLE in 1954 – not-insignificant bureaucratic and public opposition was arrayed against nuclear testing.

SANDSTONE

Operation SANDSTONE was a three-shot test series conducted at the AEC's Pacific Proving Ground in the spring of 1948.[70] This series was conducted "to proof-test new designs," and was the first test series related to weapons design since TRINITY three years earlier.[71] As a weapons design test series, SANDSTONE demonstrated important new techniques that had a profound effect upon the US nuclear stockpile.

Shortly after coming into existence with the Atomic Energy Act of 1946, the AEC submitted a report to Truman outlining the state of the nuclear industry. The report began with the statement that "the present supply of atomic bombs is very small."[72] While the number of stockpiled devices stated in this report remains

[69] For various reasons to be explored in this and later chapters, only devices with large yields were tested overseas in subsequent years.
[70] The PPG was located in the Marshall Islands and consisted principally of the Bikini and Eniwetok Atolls. SANDSTONE was conducted at Eniwetok.
[71] L.H. Berkhouse, et al., "Operation SANDSTONE: 1948," in *United States Atmospheric Nuclear Weapons Tests Nuclear Test Personnel Review* (Washington, D.C.: Defense Nuclear Agency, 1983), 17.
[72] Report to the President of the United States from the Atomic Energy Commission, January 1, – April 1, 1947, 3 April 1947; Atomic Energy: Advisory Committee to Atomic Energy: Plants, Box 175; NSC – Atomic File; PSF: Subject File, 1940-1963; Truman Papers, Truman Library.

redacted, the Defense Nuclear Agency report for Operation SANDSTONE states that, as of 27 June 1947 (when Truman gave preliminary approval for SANDSTONE and almost three months after the AEC report), the U.S. had only thirteen devices in its atomic stockpile.[73] Of just as much concern to Truman was another warning contained within the AEC report: that production of plutonium was far behind production of uranium-235.[74] This warning was particularly important, because implosion-assembly devices such as those tested in TRINITY and CROSSROADS and used at Nagasaki, which had become the so-called "standard type," used plutonium rather than uranium for fissile material. These warnings from the AEC highlighted the need for technical and theoretical developments to expand bomb production to meet defense requirements.

SANDSTONE responded to this need. Proof-tested in the three shots were weapons designs that more efficiently assembled a supercritical mass from fissile material, which, coupled with increased production rates of fissionable material, "allowed the great expansion in the U.S. stockpile evident by the end of 1949."[75]

The first two shots of SANDSTONE, X-RAY and YOKE, were of composite-core, levitated, implosion devices. The composite core was designed in the last month of the Second World War, but issues with symmetrical implosion of the levitated core were only solved in the years afterward. A mixed core of plutonium surrounded by a shell of cheaper uranium increased the yield of the device while also decreasing the cost. Levitating the core in a space inside the uranium tamper "gave the imploding

[73] Berkhouse, "Operation SANDSTONE: 1948," 18.
[74] Report to the President of the United States from the Atomic Energy Commission, January 1, – April 1, 1947, 3 April 1947; Atomic Energy: Advisory Committee to Atomic Energy: Plants, Box 175; NSC – Atomic File; PSF: Subject File, 1940-1963; Truman Papers, Truman Library.
[75] Berkhouse, "Operation SANDSTONE: 1948," 18.

shell time to acquire momentum before it hit the core," as Richard Rhodes writes, who quotes an analogy from Theodore B. Taylor: "the way to get more energy into the middle was to hit the core harder. When you hammer a nail, what do you do? Do you put the hammer on the nail and push?"[76] X-RAY and YOKE proved these design features: the X-RAY shot yielded 37 kilotons while YOKE yielded 49 kilotons, more than twice the yield of the Nagasaki "standard type."[77] More to the point, the levitated composite core design used half as much plutonium compared to that "standard type," and ten times less uranium compared to Little Boy.[78]

The third shot of SANDSTONE, shot ZEBRA, was of a levitated core, implosion design, but fuelled entirely by uranium. ZEBRA was first reported as yielding 15 kilotons but in fact yielded 18 kilotons, more than the previous all-uranium device, the gun-assembly Little Boy bomb.[79] The ZEBRA shot was also the first time that a supercritical mass of uranium had been assembled using the implosion method.[80]

Operation SANDSTONE commenced six weeks after the Communist coup in Czechoslovakia of February 1948 and concluded six weeks before the Berlin Blockade brought about the darkening of the Cold War; moreover, the X-RAY shot

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[76] Rhodes, *Dark Sun*, 188-189.
[77] "United States Nuclear Tests: July 1945 through September 1992," 2-3.
[78] Rhodes, *Dark Sun*, 320.
[79] 150117Z For McCormack Info Spence From Russell; Arabian Relations [December 10, 1947] to Council of Foreign Ministers – November-December, 1947, Box 10; Subject File; SMOF: Naval Aide to the President Files, 1945-1953; Truman Papers, Truman Library. Final yield from "United States Nuclear Tests: July 1945 through September 1992," 2-3.
[80] As an interesting side note, implosion of uranium was used in China's first nuclear test, unlike the four preceding nuclear powers, all of which used implosion of plutonium in their first tests. For an account of the Chinese pursuit of nuclear weapons, see John Lewis Wilson and Xue Litai, *China Builds the Bomb* (Stanford: Stanford University Press, 1988).

was fired less than two weeks after the Marshall Plan was signed into law. The test series of 1948, then, should be seen as part of the fabric of the developing Cold War. The efficiency of new designs demonstrated in SANDSTONE made that series, arguably, more responsible than any other test series for the large nuclear arsenals that would come to define the Cold War.

RANGER

Operation RANGER was a five-shot atmospheric test series conducted early in 1951. No nuclear tests were held during 1949 and 1950, although why this should be the case is unclear: certainly, from available documents, there does not seem to have been the same pressure on Truman to recommence testing after the Soviet atomic test of 1949 that Kennedy was to endure in 1961. Some authors have suggested that the Truman Administration used a “war scare” in 1951 to “overcome congressional resistance to stupendous military build-up once the Korean War furnished a suitable pretext,” a build-up that could easily be connected to nuclear testing.[81] A more convincing argument for this pause is related to those events in east Asia: the outbreak of the Korean War in the summer of 1950, and the perceived threat that this conflict might expand “throughout the Far East,” diminished the accessibility of the Pacific Proving Ground.[82] As a result, RANGER was the first series conducted

[81] Frank Kofsky, and Dominic Cerri, "Truman and the 1951 War Scare," *Nature, Society, and Thought* 11, no. 3 (1998): 263.
[82] Carl Maag, et al., "Operation RANGER: Shots ABLE, BAKER, EASY, BAKER-2, FOX 25 January - 6 February 1951," in *United States Atmospheric Nuclear Weapons Tests Nuclear Test Personnel Review* (Washington, D.C.: Defense Nuclear Agency, 1982), 19. Presumably, in addition to the perceived threat to shipping lanes, many of the ships assigned to test operation in the Marshall Islands were to be used in the Korean War. This argument will be revisited later in this chapter under GREENHOUSE.

in the continental United States since TRINITY of 1945, although the development of the Nevada Test Site for this purpose was not immediate.

RANGER was a weapons design test series as with TRINITY and SANDSTONE, but not in the manner of proving existing designs as with those earlier series. Rather, “the primary objective of the operation was to provide sufficient data to determine satisfactory design criteria for nuclear devices scheduled to be detonated at Operation GREENHOUSE.”[83] (GREENHOUSE was to be held at the Pacific site several months after RANGER was held in Nevada.) RANGER was conducted to test variations in core compression that, Los Alamos scientists believed, would affect the yield of devices tested in GREENHOUSE.[84] The connection between RANGER and GREENHOUSE was an intimate one. The choice of devices tested in GREENHOUSE depended “to a critical extent” on calculations tested during RANGER, and it was because “the GREENHOUSE stakes [were] so high” that great importance was attached to RANGER.[85]

Sandwiched between SANDSTONE and GREENHOUSE, the RANGER tests were of comparatively small yield. Of the five shots, the largest was FOX, which yielded 22 kilotons. Shots ABLE and EASY each yielded one kiloton, and shots BAKER and BAKER-2 each yielded 8 kilotons. All shots were airdropped, the first time since CROSSROADS ABLE, although the delivery aircraft was a B-50 rather

[83] Ibid., 17.
[84] Ibid., 18.
[85] Memorandum for the Special Committee of the National Security Council for Atomic Energy Maters from Gordon Dean, 4 January 1951; Executive Secretary’s Subject File Series, Box 4; National Security Council Staff: Papers, 1948-1961; White House Office; Dwight D. Eisenhower Library. In addition to contributions to theoretical calculations for the GREENHOUSE shots, the tests of the RANGER series determined the applicability of a new central “pit” design for existing stockpile models of atomic weapons.

than a B-29.[86] FOX was airdropped from a higher altitude than the other shots, probably because of its much greater yield.

While the primary purpose of the tests was to test designs for subsequent series, the Department of Defense also collected data relating to the effects of gamma and thermal radiation upon defensive structures. This involved the construction of shelters, fortifications and foxholes at varying distances from the hypocentre, many of which contained film packets to measure the penetration of gamma radiation and different fabrics to measure the effect of thermal radiation. These effects experiments were limited and certainly secondary to the primary objective of weapons design, and the Department of Energy defines all shots of RANGER as weapons design tests.[87]

Interestingly – perhaps because of the small yield of shots but also because of the results of SANDSTONE – for the first time at RANGER, manned aircraft conducted cloud-sampling missions. During CROSSROADS and SANDSTONE, remote-controlled drone aircraft had flown through the mushroom clouds to sample the particulate and gaseous debris (these were usually obsolete designs like the B-17); however, during RANGER, manned B-29s sampled the clouds of each shot.[88]

RANGER was an important test series less for the shots that composed it as for its place within U.S. atmospheric testing: the catalyst for the establishment of, and first series conducted within, the Nevada Test Site; the improvement of designs for the crucial GREENHOUSE tests; and for the beginning of manned cloud sampling missions, which would have lethal consequences during Operation CASTLE three years later (see Chapter Three). RANGER was also the first of the six test series

[86] The B-50 was a post-Second World War revision of the B-29 that, despite important improvements, was outwardly similar to the wartime bomber.
[87] "United States Nuclear Tests: July 1945 through September 1992," 2-3.
[88] Maag, "Operation RANGER: Shots ABLE, BAKER, EASY, BAKER-2, FOX 25 January - 6 February 1951," 55, 90, 104-05, 18, 32-33, 48.

conducted during the Korean War, and the first series conducted after the Soviet Union had acquired a very modest atomic capability.

GREENHOUSE

Operation GREENHOUSE was a four-shot test series held at Eniwetok Atoll in the Pacific Proving Grounds in the spring of 1951. It was the fourth post-war test series, and, arguably, the most important held during the Truman Administration. All shots were conducted primarily for weapons design purposes, although, as with the preceding RANGER series, secondary objectives included defense-related weapons effects studies.

The principal objectives of GREENHOUSE, as articulated to Truman while RANGER was being conducted in Nevada, were: the "proof-testing of nuclear components and associated weapons designs which may permit the attainment of much greater yields from a given amount of fissionable material, or, conversely, a given yield with the expenditure of less material"; the examination of blast effects on buildings, material, vehicles and animals; and, crucially, to gain "information concerning the feasibility of the thermonuclear weapon."[89]

GREENHOUSE was conceived upon the completion of SANDSTONE in 1948.[90] Effort toward GREENHOUSE was evident in late 1949, only days after the first Soviet test, and was spurred on by Truman's decision to commence a crash program to develop a thermonuclear weapon in January 1950. In September,

[89] Memorandum for the President from S. Everett Gleason, 31 January 1951; Executive Secretary's Subject File Series, Box 4; National Security Council Staff: Papers, 1948-1961; White House Office; Dwight D. Eisenhower Presidential Library.
[90] L.H. Berkhouse, et al., "Operation GREENHOUSE - 1951," in *United States Atmospheric Nuclear Weapons Tests Nuclear Test Personnel Review* (Washington, D.C.: Defense Nuclear Agency, 1983), 21.

preliminary costs of the series were estimated and a commander of the operation assigned.[91] In November, the AEC announced: “a new series of tests of atomic weapons is planned at the Commission’s Proving Ground at Eniwetok Atoll in the Marshall Islands.”[92] Further preparation was apparent in 1950 for what was at that time a three-shot series.[93] The period of preparation for GREENHOUSE, which partly accounts for the two-year gap in U.S. testing noted in the preceding section, was exacerbated by the requirements of the Korean War. For example, the 79th Engineer Construction Battalion, which assisted the civilian contractor in construction of facilities at Eniwetok Atoll, was to be reassigned from Eniwetok to Korea, although this deployment was contingent upon GREENHOUSE being moved to a continental test site.[94] Likewise, Rhodes relates a similar example, where the JCS were willing to delay GREENHOUSE, and thus the thermonuclear bomb, to free ships in the test task force for the blockade of North Korea.[95]

GREENHOUSE might have been postponed and the Korean War prioritised if not for Truman’s directive to the AEC of 31 January 1950 to “continue its work on all forms of atomic weapons, including the so-called hydrogen or super-bomb.”[96] While

[91] Memorandum for General Landry from Colonel Hale, 2 September 1949; Atomic Energy: President’s Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Truman Papers, Truman Library.
[92] New Series of Tests of Atomic Weapons is Planned, 29 November 1949; Atomic Energy: President’s Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Truman Papers, Truman Library.
[93] Armed Forces Participation in 1951 Atomic Weapons Proof-Testing, 16 March 1950; Statistics (Joint Task Force Three), Box 5; Quesada, Elwood R.: Papers; Dwight D. Eisenhower Library.
[94] Berkhouse, "Operation GREENHOUSE - 1951," 21, 31.
[95] Rhodes, *Dark Sun*, 442.
[96] For an excellent account of the hydrogen bomb decision in the context of “a structure of military planning,” see David Alan Rosenberg, "American Atomic

none of the devices tested during GREENHOUSE were thermonuclear devices, two involved important "thermonuclear experiments," while the GEORGE shot was "an important way station on the path to development of thermonuclear devices."[97] While RANGER was the first series conducted after Truman's 1950 directive, GREENHOUSE was the first to respond to it directly and meaningfully.[98]

Shots DOG and EASY were fired in April 1951, while, in the two-week period between them, Truman dismissed General Douglas MacArthur as Supreme Commander in Korea. Both shots were from towers, and both involved a mix of weapons design and effects experiments. Most important of these experiments was to prove and measure new fission designs – in the case of DOG, three-quarters the size and a third the weight of the models stockpiled at the time, but with much greater yield; and in the case of EASY, the same size and weight and similar yield as the stockpile model but using less fissionable material.[99] These experiments included measurements of device performance and radiation output, biomedical studies of exposed mice, instrumentation evaluation and study of cloud physics.[100] EASY

Strategy and the Hydrogen Bomb Decision," *The Journal of American History* 66, no. 1 (1979). For an account of the connections between the hydrogen bomb decision and NSC-68, see Joseph M. Siracusa, "NSC 68 and the H-Bomb Decision," in *Into the Dark House: American Diplomacy and the Ideological Origins of the Cold War* (Claremont: Regina Books, 1998). For an account of resistance to the hydrogen bomb decision, see Barton J. Bernstein, "Crossing the Rubicon: A Missed Opportunity to Stop the H-Bomb?," *International Security* 14, no. 2 (1989). See also Chapter Two of this thesis.

[97] Berkhouse, "Operation GREENHOUSE - 1951," 21.

[98] For an excellent account of the importance of GREENHOUSE to the thermonuclear program, see the chapter "Hydrodynamic Lenses and Radiation Mirrors" of Rhodes, *Dark Sun*, 455-81.

[99] Memorandum for the President from S. Everett Gleason, 31 January 1951; Executive Secretary's Subject File Series, Box 4; National Security Council Staff: Papers, 1948-1961; White House Office; Dwight D. Eisenhower Presidential Library.

[100] Berkhouse, "Operation GREENHOUSE - 1951," 103, 11.

involved more extensive effects experiments upon exposed structures at varying distances from the hypocentre.[101] DOG yielded 81 kilotons, EASY 47 kilotons.[102]

Shots GEORGE and ITEM were fired in May 1950, and sometimes referred to as the first thermonuclear and first boosted fission tests respectively. The GEORGE test was described to Truman as "determining experimentally one aspect of the feasibility of a thermonuclear weapon," specifically what came to be called the Teller-Ulam design, "the most favored [sic] current idea for initiating a thermonuclear reaction."[103] GEORGE tested the principle of using radiation to ignite deuterium-tritium (isotopes of hydrogen) by exposing a small amount of D-T to the energy of a fission bomb, and observing the effects of neutrons, temperature and density. Marshall Rosenbluth, a theoretical physicist involved in GREENHOUSE, later said that "everyone knew beforehand that it was pretty certain to work; using a huge atomic bomb to ignite the little vial of deuterium and tritium was like using a blast furnace to light a match."[104] GREENHOUSE GEORGE yielded 225 kilotons, more than every nuclear detonation before RANGER FOX combined.[105]

GREENHOUSE ITEM tested the concept of boosting rather than radiation implosion, and was described to Truman as correspondingly "less ambitious" than GEORGE.[106] The ITEM device was a uranium-235 implosion device similar to

[101] Ibid.
[102] "United States Nuclear Tests: July 1945 through September 1992," 2-3.
[103] Memorandum for the President from S. Everett Gleason, 31 January 1951; Executive Secretary's Subject File Series, Box 4; National Security Council Staff: Papers, 1948-1961; White House Office; Dwight D. Eisenhower Presidential Library.
[104] Quoted in Rhodes, *Dark Sun*, 457.
[105] This total includes both Little Boy and Fat Man. "United States Nuclear Tests: July 1945 through September 1992," 2-3.
[106] Memorandum for the President from S. Everett Gleason, 31 January 1951; Executive Secretary's Subject File Series, Box 4; National Security Council Staff: Papers, 1948-1961; White House Office; Dwight D. Eisenhower Presidential Library.

SANDSTONE ZEBRA except that much of its yield was derived from the inclusion of D-T fusion fuel, the fusion of which increased the neutron count and the rate of fission reactions within the uranium, and thus boosted the yield. GREENHOUSE ITEM yielded 45.5 kilotons, more than twice that of SANDSTONE ZEBRA.[107] Observers of ITEM also noted that particles from its fallout were large enough to be felt on their hands and faces.[108]

GREENHOUSE was likely the most significant of the test series conducted under Truman. It stands out in the table that appended to this thesis for a remarkable gulf between number of shots and total yield. This gulf, inverted as it was, was due to the relatively high yield of each of the shots, expressed most clearly in GEORGE. As SANDSTONE demonstrated the potential for increased stockpiles through more efficient fission reactions in limited fissile material, so too did GREENHOUSE demonstrate the ability to vastly improve yield through introduction of fusion material. In four test series since wartime use against Japan, the United States had achieved a tenfold increase in the yield of its nuclear weapons. More important still, GREENHOUSE proved the practicality of radiation implosion, the crucial step to the thermonuclear bomb. Indeed, the proof borne out in GREENHOUSE GEORGE "led directly to the first successful thermonuclear test, [IVY MIKE], some 16 months later."[109]

BUSTER-JANGLE

Operation BUSTER-JANGLE was a combined Atomic Energy Commission and Department of Defense test series conducted in late 1951 at the Nevada Test Site.

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107 "United States Nuclear Tests: July 1945 through September 1992," 2-3.
108 Berkhouse, "Operation GREENHOUSE - 1951," 128.
109 Ibid., 21.

It was a seven-shot series that combined weapons design and weapons effects experiments and involved the first of the DESERT ROCK military exercises.

BUSTER-JANGLE was born as a very different test series to what was eventually conducted: it was first known as Operation WINDSTORM and was to determine the effects of underground explosions in the same manner that previous tests had determined the effects of atmospheric and underwater explosions.[110] WINDSTORM was to be held on Amchitka Island, at the far end of the Aleutian Islands, between Alaska and the Soviet Union. Internal opposition within the Truman Administration to the use of Amchitka for nuclear testing was registered from at least the Department of State and the Department of the Interior.[111] The use of Amchitka for WINDSTORM was eventually abandoned not because of concerns about the provocative character of tests so close to the borders of the Soviet Union or about the native population of sea otters, but rather because a "detailed exploration of the site has revealed geological conditions less favourable [to the conduct of an underground nuclear test] than preliminary surveys had indicated."[112]

After casting about for a more appropriate test site – a process during which potential sites in Canada, Australia and the Caribbean were rejected – the substance of

[110] Memorandum for the President from James S. Lay, Jr., 27 October 1950; Executive Secretary's Subject File Series, Box 4; National Security Council Staff: Papers, 1948-1961; White House Office; Dwight S. Eisenhower Library.
[111] Dale E. Doty to James S. Lay, Jr., 13 October 1950; Executive Secretary's Subject File Series, Box 4; National Security Council Staff: Papers, 1948-1961; White House Office; Dwight S. Eisenhower Library.
[112] Memorandum for the Executive Secretary, National Security Council from the Secretary of Defense, 21 May 1951; Atomic Energy: President's Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Truman Papers, Truman Library. Amchitka Island would not completely escape nuclear testing: it was used for underground tests between 1965 and 1971. For an account of the use of Amchitka as a nuclear test range, see Dean Kohlhoff, *Amchitka and the Bomb: Nuclear Testing in Alaska* (Seattle: University of Washington Press, 2002).

the WINDSTORM series was designated for the Nevada site used for Operation RANGER earlier in 1951, and the entire test series renamed Operation JANGLE.[113] The AEC submitted to Truman in October 1951 that JANGLE be merged with a weapons design test series named BUSTER, and Operation BUSTER-JANGLE was approved by Truman on 9 October.[114] The two halves of this combined test series were distinguishable by their sponsor (the Department of Defense was involved only in JANGLE shots, while Los Alamos sponsored both BUSTER and JANGLE) and by their purpose (all shots of BUSTER were weapons-related tests, while the JANGLE shots were weapons effects tests).[115]

Interestingly, there was discussion between the White House and the AEC regarding the possibility that Truman himself would attend at least one of the BUSTER-JANGLE tests. Gordon Dean, chairman of the AEC, wrote to Truman less than a week after the president's approval of the series to remind him of an earlier

113 Regarding the search for an appropriate test location: Memorandum for the President from James S. Lay, Jr., 27 October 1950; Executive Secretary's Subject File Series, Box 4; National Security Council Staff: Papers, 1948-1961; White House Office; Dwight S. Eisenhower Library. Regarding the change in designation from WINDSTORM to JANGLE: Memorandum for James S. Lay from Gordon Dean, 2 October 1951; Executive Secretary's Subject File Series, Box 4; National Security Council Staff: Papers, 1948-1961; White House Office; Dwight D. Eisenhower Library.

114 Regarding the merging of BUSTER and JANGLE: Memorandum for James S. Lay from Gordon Dean, 2 October 1951; Executive Secretary's Subject File Series, Box 4; National Security Council Staff: Papers, 1948-1961; White House Office; Dwight D. Eisenhower Library. Regarding Presidential approval for BUSTER-JANGLE: Request for Presidential Approval for BUSTER-JANGLE, 9 October 1951; Atomic Energy: President's Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Truman Papers, Truman Library.

115 "United States Nuclear Tests: July 1945 through September 1992," 2-3.

discussion and to suggest a number of shots the president might witness.[116] Truman responded the next day with an implicit rejection, stating that, "as conditions look now, I doubt very much whether I will be able to be present at any of them [test shots]."[117]

The five shots of BUSTER were focused on weapons development, but information about those developments remains redacted. Dean related to Truman the general objective – similar to preceding fission weapons development tests – to "find more efficient ways of using fissionable material."[118] We also know that BUSTER EASY, the fifth shot, was of an untested design intended for stockpile and much smaller than previous designs.[119] The BUSTER shots were of relatively low yield, compared to GREENHOUSE: ABLE yielded 0.1 kilotons; BAKER yielded 3.5 kilotons; CHARLIE yielded 14 kilotons; DOG yielded 21 kilotons; while EASY yielded the highest energy of the series at 31 kilotons.[120] It seems likely from its yield and the comparative yields of the other shots in the series that ABLE was a fizzle – an unsuccessful test in which the device fails to achieve its designed yield.

The two shots of JANGLE were conducted to determine the effects of underground nuclear explosions, specifically, to evaluate "types and numbers of

[116] Gordon Dean to President Truman, 15 October 1951; Atomic Energy: President's Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Truman Papers, Truman Library.
[117] Ibid.
[118] Ibid.
[119] Ibid. It was this shot that Dean most recommended Truman witness.
[120] "United States Nuclear Tests: July 1945 through September 1992," 2-3. It is interesting to note that BUSTER CHARLIE had the same yield as Little Boy and BUSTER DOG the same as Fat Man.

[ground] penetrating weapons required for stockpile."[121] Two low-yield shots were conducted, one on the surface and one underground, so as to compare the effects of surface and penetrating atomic detonations.[122] The JANGLE shots responded to observations from earlier test series, which suggested that certain structures, such as airfields, roads and underground installations, were "relatively immune" to airburst detonations, and the JCS identified a need for a ground-penetrating weapon to destroy these targets.[123] Because of the comparative delicacy of the implosion-assembly device, the gun-assembly device was tested for ground-penetrating warheads – for the first time since Hiroshima. SUGAR, the surface shot, and UNCLE, the underground shot, each yielded 1.2 kilotons.[124]

Most significant for BUSTER-JANGLE was the participation of Defense personnel in the first nuclear military exercises, known as DESERT ROCK I, II and III.[125] These troop training and military exercises were held because of the "increasing dependence" of U.S. military upon its atomic capability, and were conducted to "test tactics and protective measures for use during a nuclear conflict."[126] The three DESERT ROCK exercises involved approximately 6,500 personnel. They included observations of nuclear detonations and post-shot inspection of equipment affected by

[121] Memorandum for James S. Lay from Gordon Dean, 2 October 1951; Executive Secretary's Subject File Series, Box 4; National Security Council Staff: Papers, 1948-1961; White House Office; Dwight D. Eisenhower Library.
[122] Ibid. The measurement of the underground detonation, presumably, required certain geological conditions that Amchitka Island could not provide.
[123] Memorandum for the President from James S. Lay, Jr., 27 October 1950; Executive Secretary's Subject File Series, Box 4; National Security Council Staff: Papers, 1948-1961; White House Office; Dwight S. Eisenhower Library.
[124] "United States Nuclear Tests: July 1945 through September 1992," 2-3.
[125] DESRT ROCK I was held as part of BUSTER DOG, while DESERT ROCK II was held at JANGLE SUGAR and DESERT ROCK III at JANGLE UNCLE.
[126] Jean Ponton, et al., "Operation BUSTER-JANGLE, 1951," in *United States Atmospheric Weapons Tests Nuclear Test Personnel Review* (Washington, D.C.: Defense Nuclear Agency, 1982), 46.

the blast. DESERT ROCK I involved a troop manoeuvre, in which a reinforced battalion of airborne troops, having observed BUSTER DOG from a safe distance, advanced toward ground zero in attack formation.[127] At their closest approach, the soldiers of this battalion were less than five hundred meters from the hypocentre.[128]

BUSTER-JANGLE continued the emphasis upon weapons design tests carried out during the Truman Administration. As with preceding series, the goal of these weapons design tests was more efficient use of fissionable material, including more efficient methods to assemble supercritical masses of that material. The cratering shots of JANGLE were also the first underground tests conducted by the United States, but these were carried out for weapons design purposes rather than for seismic detection purposes as was the case late in the Eisenhower Administration when underground testing received greater attention.[129]

TUMBLER-SNAPPER

Operation TUMBLER-SNAPPER was an eight-shot test series held in the spring of 1952. It was the sixth post-war test series and the third held at the Nevada Test Site. As with the preceding BUSTER-JANGLE series, TUMBLER-SNAPPER was conceived as two separate series that were conducted together by the AEC and the Department of Defense. Likewise, TUMBLER-SNAPPER involved weapons designs and effects experiments, and further military exercises as part of the DESERT ROCK program.

The two distinct series that became two phases of the same series, TUMBLER and SNAPPER, were amalgamated due to the results of the BUSTER-JANGLE

[127] Ibid., 54-55.
[128] Ibid.
[129] See Chapters Three and Four.

series. Indeterminate plans were made in 1951 for a test series in 1952 to be called Operation SNAPPER; to this planned series additional shots were added following the results of BUSTER-JANGLE. The additional shots, Operation TUMBLER, included some experiments already covered by SNAPPER, and, because of this overlap, the two series were combined into one operation.[130] As carried out, TUMBLER involved weapons effects tests that sought to confirm data observed from BUSTER-JANGLE, while SNAPPER involved tests of weapons designs for inclusion in the nuclear arsenal and techniques for measuring thermal radiation for the forthcoming IVY series.[131]

Results of the preceding test series determined many of the experiments held at TUMBLER-SNAPPER. Weapons effects measurements from the BUSTER shots of 1951 had suggested a significant miscalculation of the air blast pressures – as much as a third to half – then being used "for planning purposes by the Armed Services."[132] This miscalculation was significant. It affected calculations for the optimum heights of airburst detonations and blast overpressure, consequently decreasing the damage and area of damage to which a target might be subjected.[133] With some degree of urgency, Robert A. Lovett, the secretary of defense, wrote a memorandum for the National Security Council (NSC) suggesting that, should the BUSTER data be confirmed, "the resultant effectiveness of the atomic weapons stockpile [would be

[130] Jean Ponton, et al., "Operation TUMBLER-SNAPPER 1952," in *United States Atmospheric Nuclear Weapons Tests Nuclear Test Personnel Review* (Washington, D.C.: Defense Nuclear Agency, 1982), 26-28.
[131] Ibid., 28.
[132] Memorandum for the Executive Secretary, National Security Council, 16 January 1952; Atomic Energy: President's Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Papers of Harry S. Truman, Truman Library.
[133] Ibid. Height is used to measure vertical distances from the surface, as in an airburst detonation, while altitude is used to measure vertical distance from mean sea level.

decreased] by a factor of 4 or more."[134] Lovett recommended that three shots be fired "as soon as is practicable";[135] Gordon Dean, in his own letter dated two weeks later, stated that while the AEC was "in complete sympathy" with Lovett's request, the NSC should rather seek presidential approval in principle only for the merging of TUMBLER and SNAPPER.[136] Truman approved TUMBLER on 20 February, and TUMBLER-SNAPPER one month later.[137]

Four of the shots of TUMBLER-SNAPPER were airdropped and the remaining four shots were fired from towers; only two shots were for the explicit purpose of weapons effects testing. Shots ABLE through DOG were airdropped, and varied in yield from the 1 kiloton of ABLE and BAKER, through 19 kilotons and 31 kilotons for DOG and CHARLIE respectively.[138] The four tower shots varied in yield between the 11 kilotons of FOX to the 15 kilotons of GEORGE.[139] ABLE and BAKER were the weapons effects tests of the series, although CHARLIE, DOG, EASY and HOW also involved weapons effects programs of secondary importance to

[134] Ibid.
[135] Ibid.
[136] Gordon Dean to James S. Lay, Jr., 30 January 1952; Executive Secretary's Subject File, Box 4; National Security Council Staff: Papers, 1948-1961; White House Office; Dwight D. Eisenhower Library.
[137] Regarding the approval of TUMBLER: Memorandum for the President from James S. Lay, Jr., 20 February 1952; Atomic Energy: President's Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Papers of Harry S. Truman, Truman Library. Regarding the approval of TUMBLER-SNAPPER: Memorandum for the President from James S. Lay, Jr., 21 March 1952; Atomic Energy: President's Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Papers of Harry S. Truman, Truman Library.
[138] "United States Nuclear Tests: July 1945 through September 1992," 4-5. As with previous series, the larger yield shots were detonated at a greater height than those of smaller yield, presumably to prevent interaction between the fireball and the surface and the resulting fallout. Ponton, "Operation TUMBLER-SNAPPER 1952," 35.
[139] "United States Nuclear Tests: July 1945 through September 1992," 4-5.

weapons related purposes.[140] As with BUSTER-JANGLE, the specific purposes of weapons effects studies are more readily available in the archival sources than the specific purposes of weapons designs studies; nonetheless, it would appear from statements made by Gordon Dean and by the yield of the weapons design shots that efforts were made through TUMBLER-SNAPPER to miniaturise and diversify the range of tactical nuclear weapons available in the atomic arsenal.[141]

Exercise DESERT ROCK IV was held as part of the TUMBLER-SNAPPER series. All shots except HOW were observed by members of the armed forces so as to familiarise these soldiers with “the characteristic effects of nuclear detonations.”[142] Shots CHARLIE, DOG and FOX featured troop manoeuvres involving all three branches of the armed forces that were “to determine whether standard ground tactical movements could be employed under the radiological conditions resulting from the use of nuclear weapons.”[143] Troops observed the shots from trenches and fortifications as close as 6,400 meters from the hypocentre and then, following the detonation, advanced toward the exercise objective. The largest of the manoeuvres was conducted by the Marine Corps at shot DOG, and involved almost two thousand participants.[144]

TUMBLER-SNAPPER was the last of the test series conducted before the first test of a thermonuclear weapon as part of Operation IVY four months later. In that respect, this series can be seen as the last of the fission age. Both the weapons design and weapons effects tests speak to a developing understanding of nuclear

[140] Ponton, "Operation TUMBLER-SNAPPER 1952," 80, 85, 90, 94, 97, 101.
[141] Ibid., 25. Efforts, likely, spurred by the ongoing war in Korea.
[142] Ibid., 64-65.
[143] Ibid., 65, 67.
[144] Ibid., 65, 70. The marines halted their exercise 820 meters from ground zero due to intense radiation. Ibid, 5.

weapons in a tactical role on behalf of the United States, an understanding that presaged the defense policies of the Eisenhower Administration – which would take office barely six months after the conclusion of TUMBLER-SNAPPER.

Conclusion

The nuclear test series conducted during the Truman Administration were foremost weapons design tests. Improvements in weapons design and theoretical understanding permitted a doubling of yield over the weapons used against Japan in two test series, and a tenfold increase in yield in four test series. Moreover, these improvements permitted a far larger and more varied atomic arsenal through more efficient use of the limited stockpile of fissile material. In this regard, Operations SANDSTONE and GREENHOUSE were the most crucial test series – SANDSTONE for making possible for the first time the large nuclear arsenals that came to define the Cold War, and GREENHOUSE for taking a definitive and meaningful step toward the thermonuclear bomb and the dramatic expansion in yield associated with that step.

These test series were not exclusively for the purpose of weapons design, however. Weapons effects studies, whether the primary rationale for a shot like those of CROSSROADS or a secondary objective like the shots of RANGER, affected a more comprehensive and nuanced understanding of both the strategic and, eventually, battlefield applications of nuclear weapons, culminating in the tactical exercises of BUSTER-JANGLE and TUMBLER-SNAPPER. Knowledge of the effects of nuclear weapons shaped plans for their use as much as their availability and their yield. This relationship was seen in the TUMBLER-SNAPPER series, where tests were conducted based on information that would profoundly affect war plans for the use of nuclear weapons.

Very few if any of these developments would have been possible without testing. An argument might be made that nuclear testing merely confirmed theoretical calculations, as was the case with the test of radiation burn of deuterium-tritium of GREENHOUSE GEORGE. But that argument ignores the very real value of proof testing – the demonstration and measurement of a theoretical or technical development being of crucial importance at TRINITY, SANDSTONE and GREENHOUSE, for example. Moreover, testing not infrequently presented entirely unexpected data that might not have been learned otherwise; this was more so the case during the Eisenhower Administration, but, during the Truman Administration, we find an example in the unexpected results of the BUSTER series, which prompted the subsequent TUMBLER shots.

The emphasis upon weapons design tests that characterised the years 1945-1952 is perhaps a natural result of the infancy of nuclear weapons technology. But it was likely also the result of the glimpsed view of the thermonuclear bomb on the theoretical horizon – and Truman's decision of 1950 to pursue that avenue of weapons technology. During these years, the rivalry between Moscow and Washington deepened, while the United States fought a war in Korea and developed its nuclear weapons technology to the point that, one week before the 1952 Presidential election, it tested its first thermonuclear weapon with the IVY MIKE shot. I return to Operation IVY in Chapter Three; in the next chapter, I further discuss the paradigm of weapons design and development so prevalent between 1945-1952.

Chapter Two

The Normalisation of Nuclear Testing

"The profundity of the atomic crisis which has now overtaken us cannot, in my judgment, be exaggerated."

Brien McMahon, 21 November 1949.

"If a test of a thermonuclear weapon proves successful, the pressures to produce and stockpile such weapons…will be greatly increased."

Terms of Reference to NSC-68, 14 April 1950.

Although in hindsight it appears a natural, even inevitable, progression from the Manhattan Project, that the United States should conduct nuclear weapons tests was not a foregone conclusion. Many structural forces certainly operated to affect this conclusion, including the investment of scientific, technical and military progress in nuclear weapons, and the perception that nuclear weapons were both war-winning *and* peace-ensuring weapons that deserved further development. But in the aftermath of their wartime use against Japan, it was not assured that testing of nuclear weapons would assume the pervasive and threatening character that was the case over the next two decades.

The nuclear test series conducted under Truman offer an opportunity to explore the normalisation of weapons testing. It was these series that established the precedent for the U.S. to test, while also determining the form and character of subsequent tests. These series were also the earliest opportunity to avert the normalisation of nuclear testing. The best example of normalisation was Operation

CROSSROADS, against which loud voices citing rational arguments were raised, and which was conducted simultaneously with diplomatic efforts that ostensibly sought to arrest nuclear weapons development. Through an examination of the Truman test series it is possible to identify the establishment of that norm and investigate also the interaction of various events – such as the first Soviet nuclear test in August 1949, the publication of NSC-68 in April 1950, and the start of the Korean War in June 1950 – that together crystallised the norm of nuclear testing.

The idea of norms and normative behaviour is important to the study of nuclear weapons and strategy for their use (or non-use). Most helpful for this thesis is the excellent work of Scott D. Sagan and Nina Tannenwald. Neither discuss norms in relation to nuclear testing, but both have written useful works that are applicable to testing. Sagan's multicausal analysis of why states build nuclear weapons identifies one potential reason: the "norms model," through which "state behaviour is determined…by deeper norms and shared beliefs about what actions are legitimate and appropriate in international relations."[1] This point is important because the shared beliefs regarding nuclear testing were constructed during the Truman years and changed during the Eisenhower years, such that testing was no longer "legitimate and appropriate." Tannenwald's constructivist account has examined the taboo on the use of nuclear weapons and discusses norms in terms of nuclear non-use; she identifies the crucial, larger issue of how norms affect a state's capabilities and behaviour.[2] In

[1] Scott D. Sagan, "Why Do States Build Nuclear Weapons?: Three Models in Search of a Bomb," *International Security* 21, no. 3 (1996-1997): 73. As part of this model, Sagan also discusses nuclear weapons as a normative symbol of state identity, in a manner not dissimilar to the way battleships partly defined the identity of great powers in the late nineteenth and early twentieth centuries.

[2] Nina Tannenwald, "The Nuclear Taboo: The United States and the Normative Basis of Nuclear Non-Use," *International Organization* 53, no. 3 (1999): 434. Tannenwald further developed this article into a book. See Tannenwald, *The Nuclear Taboo: The*

both cases, these authors have outlined a conception of norms similar to that used in this chapter: a pattern of state behaviour that is legitimised and as such comes to be accepted as convention. This chapter shall explore how the nuclear test series held while Truman was president came to establish this convention and normalise the act of nuclear testing until at least 1958 and, to a lesser degree, until 1963.

In Chapter One, I briefly described seven nuclear test series conducted by the United States during the Truman years. This chapter shall specifically explore these test series through the lens of norms and normative testing. This lens is important because it helps to explain how nuclear testing came to be accepted as a legitimate state act, and because it helps to contextualise the expansion, limitation and then abandonment of atmospheric testing during the Eisenhower and Kennedy Administrations. Moreover, this chapter will illustrate the importance of U.S. nuclear testing within the early Cold War period.

The Hiroshima Decision

Analysis of the decision to use atomic weapons against Japan, specifically the use of the Little Boy device above Hiroshima, is extensive and important to discussion of nuclear strategy. Much of this literature is related to the twin problems of the morality of the atomic bombing of Japan and the extent of its effect upon Japanese surrender – both issues raised in Gar Alperovitz's historiographically significant *Atomic Diplomacy.*[3] Although shown by authors like Robert James

United States and the Non-Use of Nuclear Weapons since 1945 (New York: Cambridge University Press, 2007).

[3] Alperovitz's work is significant mostly for introducing a contentious theory and its divisive effect on subsequent literature. It was also among the first works to revise the orthodoxy regarding the use of atomic weapons against Japan. Gar Alperovitz, *Atomic Diplomacy: Hiroshima and Potsdam* (New York: Simon and Schuster, 1965).

Maddox to be less useful for the history of the Hiroshima bombing, Alperovitz's notion of atomic diplomacy – in which atomic weapons serve as political tools to affect diplomatic results – is nonetheless useful for study of nuclear weapons testing. Analysis of what Wilson Miscamble simply calls "the Hiroshima decision" is also useful for understanding nuclear testing.[4] The exploration of practical alternatives to the sobering use of atomic weapons above Hiroshima is central to any debate of the morality of the decision – and, so too, to a fuller understanding of nuclear testing.[5]

Beginning in 1944 and intensifying in 1945 was a discussion within the United States military and the scientists of the Manhattan Project regarding the target of the atomic bomb.[6] This discussion concluded with the selection of Hiroshima, but the path to this decision is almost as important for understanding nuclear testing as the TRINITY test. Discarded along the way to this conclusion were non-strategic and

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Regarding the Japanese surrender, most convincing to this author are the words of Lawrence Freedman: "If the bomb did have a role it was in accelerating and intensifying the process of political change [toward Tokyo's surrender]. But even here caution is due. The dropping of the bomb was not the only shock the Japanese received in the four days beginning on 6 August 1945. Combined with the atom bomb was the Soviet Union's entry into the war against Japan." Freedman, *The Evolution of Nuclear Strategy*: 18-19.

[4] See chapter six of Wilson Miscamble, *From Roosevelt to Truman: Potsdam, Hiroshima, and the Cold War* (New York: Cambridge, 2007). Literature regarding Hiroshima can be crudely labelled as orthodox or revisionist, with Alperovitz's work marking the rise of revisionism. Early defense of the decision came from Stimson himself. Henry Lewis Stimson, "The Decision to Use the Atomic Bomb," *Harper's Magazine* (February 1947). A good example of the orthodox position can be found in Herbert Feis, *Japan Subdued: The Atomic Bomb and the End of the War in the Pacific* (Princeton: Princeton University Press, 1961).

[5] Recent scholarship that covers both morality and effect can be found in Sean L. Malloy, "'A Very Pleasant Way to Die': Radiation Effects and the Decision to Use the Atomic Bomb Against Japan," *Diplomatic History* 36, no. 3 (June 2012).

[6] The decisions of the Target Committee have been extensively explored in the literature and their every decision will not be covered in this thesis. For a good and recent account of the Committee's discussions, see chapter eight of Paul Ham, *Hiroshima Nagasaki* (Sydney: Harper Collins Publishers, 2011).

even non-combat uses for the first atomic bomb. Los Alamos scientists proposed the first of these potential uses in 1944 when they suggested that the atomic bomb should be used against Japanese "fleet concentrations," specifically the naval base of Truk.[7] This proposal was rejected not by committee but by the course of the war in the Pacific: by mid-1945, when the atomic bombs became available, most of the Japanese fleet had been sunk through naval and air action, and Truk had been overcome through conventional air attack. Had the course of the war progressed differently it would still have been unlikely that concentrations of the Japanese navy would have been targeted for the same reasons – deliverability and effect – that determined that Hiroshima and Nagasaki should be bombed. Nonetheless, it is worthwhile if ahistorical to appreciate that the first use of an atomic bomb might have been tactical rather than strategic, with all the implications for the established precedent that would entail.

It was also suggested by Manhattan Project scientists and members of the Targeting Committee that the first atomic bomb be detonated as a demonstration rather than as a weapon. At a meeting on 31 May 1945 of the Interim Committee – the effective, wartime predecessor of the AEC – physicist Ernest Lawrence suggested a demonstration of the atomic bomb, rather than combat use, to "show off its power and intimidate the Japanese" – a notion that the Targeting Committee, including J. Robert Oppenheimer, had rejected less than a fortnight before.[8] Here again the idea

[7] William A. Shurcliffe, *Bombs at Bikini: The Official Report of Operation Crossroads* (New York: W. H. Wise & Co., Inc., 1947), 9; James P. Delgado, et al., "The Archaeology of the Atomic Bomb: A Submerged Cultural Resources Assessment of the Sunken Fleet of Operation Crossroads at Bikini and Kwajalein Atoll Lagoons," (Sante Fe, New Mexico: United States Department of the Interior, 1991), 14; Graybar, "The 1946 Atomic Bomb Tests: Atomic Diplomacy or Bureaucratic Infighting?," 892.
[8] Ham, *Hiroshima Nagasaki*: 157.

was rejected, this time by James Byrnes (who would one month later become secretary of state), with Henry Stimson and Oppenheimer concurring that, as Stimson later wrote, "nothing would have been more damaging to our effort to obtain surrender than a warning or a demonstration followed by a dud."[9] Oppenheimer added that it was unlikely that a demonstration, such as an airburst in the skies off Japan, would have impressed the Japanese.[10] The idea did not go away, however. In June, a committee of Manhattan Project scientists from the University of Chicago, chaired by Nobel laureate James Franck, penned the Franck Report, which argued against the military use of the bomb.[11] Citing the effect on the United States' moral authority and the possibility of international control of atomic energy, the Franck Report concluded that "much more favourable conditions for the achievement of such an agreement [an international agreement on the control of atomic weapons] could be created if nuclear bombs were first revealed to the world by a demonstration in an appropriately selected uninhabited area."[12] The Science Panel's Report to the Interim Committee, signed by Oppenheimer and submitted in the same week as the Franck Report, commented upon the recommendation of the scientists of the University of Chicago but again rejected their suggestion. The panel noted "those who advocate a purely

[9] P. R. Baker (ed.), *The Atomic Bomb: The Great Decision* (New York: Holt, Rinehart and Winston, 1968), 19; Ham, *Hiroshima Nagasaki*: 157.
[10] Max Hastings, *Retribution: The Battle for Japan, 1944-45* (New York: Alfred A. Knopf, 2007), 455.
[11] Other members of the committee included Leo Szilard, who first conceived the idea of a self-sustaining nuclear chain reaction and who oversaw the assembly of the world's first nuclear reactor at the University of Chicago; Eugene Rabinowitch, who later lobbied against the hydrogen bomb; and Glenn Seaborg, who would become chairman of the AEC under presidents Kennedy and Johnson.
[12] Report of the Committee on Political and Social Problems, 11 June 1945, quoted in Cynthia C. Kelly (ed.), *The Manhattan Project: The Birth of the Atomic Bomb in the Words of Its Creators, Eyewitnesses and Historians* (New York: Black Dog & Levanthal Publishers, 2007), 289.

technical demonstration" but stated that "we can propose no technical demonstration likely to bring an end to the war" and, importantly, "we see no acceptable alternative to direct military use."[13] In his memoirs, Truman attributed to this recommendation from Oppenheimer and the Science Panel, in the words of Paul Ham, "a critical role in influencing his decision of how and where to use the bomb."[14]

It is convenient to consider the kind of demonstrative test for which Lawrence and Franck argued, even if it remained a rejected suggestion. While the demonstrative use of a nuclear detonation would not likely advance nuclear weapons design or determine weapons effects, it would in both a technical and a political sense prove that the weapon worked as designed. This reason fulfils one of the criteria by which the Department of Energy defines a nuclear weapons test, as outlined in Chapter One.[15] Had such a non-combat shot been conducted, history may have accepted another purpose to nuclear weapons and, specifically, another purpose to nuclear tests to go with weapons design, weapons effects and weapons proof tests. Moreover, the very discussion of a noncombat demonstration of an atomic weapon in May and June 1945 speaks to early thinking that a nuclear test alone could affect political results, at least among some Manhattan Project scientists, and, however vaguely, conveys Alperovitzian notions of atomic diplomacy. This thinking lends the discussions over these two months in 1945 a historical significance far greater than an abandoned idea on the path to the atomic bombing of Hiroshima. Indeed, similar arguments regarding the political consequences of nuclear testing would emerge again in the following year during preparations for the CROSSROADS tests at Bikini Atoll.

[13] Science Panel's Report to the Interim Committee, Recommendations on the Immediate Use of Nuclear Weapons, 16 June 1945; quoted in ibid., 290-91.
[14] Ham, *Hiroshima Nagasaki*: 162.
[15] "United States Nuclear Tests: July 1945 through September 1992," vii. See also Chapter One.

CROSSROADS and the Emergence of a Norm

The first nuclear test series conducted by the United States was Operation CROSSROADS, which was conducted in July 1946 at Bikini Atoll in the Pacific Ocean. In Chapter One I explored the historical narrative of CROSSROADS, including the opposition that emerged to the tests in early- and mid-1946. While it is notable that nuclear testing was from its very beginning opposed by scientists, sections of the government and the citizenry, it is of greater interest that the arguments militated against CROSSROADS outlined important characteristics of the series itself. Here I am thinking of CROSSROADS as an early, if not the earliest, candidate for that Alperovitzian term “atomic diplomacy,” while also recognising this test series as “one of the central events of the immediate postwar years.”[16] CROSSROADS was a particularly significant test series for three reasons: the implied rejection of concurrent negotiations for international control of atomic weapons, the competition that characterised the U.S. military in 1946, and the relationship between that rivalry and the limited atomic stockpile of that year.

Opposition to the CROSSROADS tests was widespread, and was noted in Chapter One. One of the arguments raised in opposition to the tests was that CROSSROADS would adversely affect diplomatic efforts toward the international

[16] Lloyd J. Graybar’s excellent article was one of the first to shift the focus of analysis regarding “atomic diplomacy” from Hiroshima and Nagasaki to the 1946 Bikini tests. He notes that “while historians have engaged in heated exchanges over the issue of whether Hiroshima and Nagasaki represented atomic diplomacy, they have, with few exceptions, failed to discuss whether the Bikini tests had political goals of the sort attributed to the nuclear attacks on those Japanese cities.” Graybar ultimately concludes that CROSSROADS was not an example of “atomic diplomacy.” Graybar, "The 1946 Atomic Bomb Tests: Atomic Diplomacy or Bureaucratic Infighting?," 889, 91.

control of atomic energy.[17] What was understood by this argument was that the CROSSROADS tests were an implicit rejection of the international negotiations. The Baruch Plan was submitted by the United States to the United Nations two weeks before the ABLE shot was fired, and there was an undeniable dissonance to Washington negotiating for international control of nuclear weapons while simultaneously testing those same weapons on a fleet of warships.[18] This dissonance was noted in the U.S. Senate during a debate regarding the Navy's use of target warships in CROSSROADS, on the same day that the Baruch Plan was presented to the United Nations. Senator Scott Lucas (D-IL) noted that "if the United States wishes to strengthen Mr. Baruch's hand…if the United States wishes to show the world that we mean business in the renunciation of the atom bomb as an instrument of warfare, we should now call off this test."[19] The Soviet Union, through *Pravda*, also made much of this point by saying that "the tests are not preparations to destroy the weapon but to work towards its perfection."[20] Lloyd Graybar however concludes that while the timing of CROSSROADS relative to the international negotiations was "regrettable," such was the succession of international events and climate of solidifying tensions that at no other point in 1946 could the Bikini tests have been

[17] Graybar cites a sample of letters from the public opposing CROSSROADS to show that 45 per cent of these letters opposed the tests based on the use of live animals, while only 17 per cent opposed the tests based on concerns for international relations. Ibid., 896-97.

[18] For a good and recent overview of the negotiations for the international control of atomic weapons, including the Baruch Plan, see chapter three of Richard Dean Burns, and Siracusa, Joseph M., *A Global History of the Nuclear Arms Race: Weapons, Strategy, and Politics*, vol. 1 (Santa Barbara: Praeger Security International, 2013).

[19] Quoted in Weisgall, *Operation Crossroads: The Atomic Tests at Bikini Atoll*: 101. Senator Ralph Brewster (R-ME) defended CROSSROADS with the rejoinder "speak softly and carry a big stick."

[20] Ibid., 254.

held without "risking the appearance of atomic diplomacy."[21] In a similar vein, Samuel Williamson, Jr. and Steven Rearden portray a Truman defensive of the Baruch Plan, and who desired "to avoid doing anything that might torpedo" that proposal.[22] More to the point, the Baruch Plan was so inherently flawed that its acceptance by the Soviet Union is almost unimaginable even without the concurrent CROSSROADS tests.[23]

CROSSROADS was more the result of rivalry between the branches of the United States military and the dynamics of the forthcoming unification of those branches than it was a particular example of atomic diplomacy. The process leading to the unification of the War and Navy Departments – characterised as "one of the most bitter and divisive bureaucratic quarrels in American history" – was taking place while the CROSSROADS tests were being planned and prepared.[24] Nonetheless, the first test series conducted by the United States – indeed, in history – had diplomatic implications even if they were unintentional. CROSSROADS should be seen alongside George F. Kennan's "long telegram," Winston Churchill's Fulton speech describing an "iron curtain," the failure of the Soviet Union to promptly withdraw

[21] Graybar, "The 1946 Atomic Bomb Tests: Atomic Diplomacy or Bureaucratic Infighting?," 902-3.
[22] Samuel Williamson Jr. and Steven L. Rearden, *The Origins of U.S. Nuclear Strategy, 1945-1953* (New York: St. Martin's Press, 1993).
[23] Dean Acheson, coauthor or the Acheson-Lilienthal Report on which Baruch based his plan and later secretary of state under Truman, described the Baruch Plan as "unrealistic, silly…mischievous in the extreme." Quoted in Weisgall, *Operation Crossroads: The Atomic Tests at Bikini Atoll*: 100.
[24] Indeed, on 15 June 1946, just one day after the Baruch Plan was submitted to the U.N. and two weeks before CROSSROADS ABLE, Truman compromised on the issue of unification: he favoured a single military department with three branches, but "endorsed in principle" the Navy retaining land-based aviation and a separate Marine Corps. Williamson Jr., *The Origins of U.S. Nuclear Strategy, 1945-1953*: 55.

from Iran, and Moscow's demand for control of the Dardanelles, as crucial and early events that came to define the Cold War – or at least make its contours known.

As the first of the U.S. nuclear test series, it is worth also pausing to reflect on the investment that the United States made in CROSSROADS. David Alan Rosenberg has shown the limitations to the U.S. stockpile in the years of atomic monopoly.[25] As of July 1946, when CROSSROADS was held, there were only nine atomic bombs in the U.S. stockpile; it was planned to expend a third of this arsenal during the Bikini tests.[26] With the cancellation of the third CHARLIE shot, CROSSROADS expended as many warheads as the sum of the U.S. arsenal at the end of 1945.[27] This was a remarkable investment, one described as almost ostentatious by James Delgado et. al., who characterised CROSSROADS as:

> …a demonstration that the United States was now the world leader; it alone possessed the secret of nuclear power, it had a stockpile of atomic bombs capable of being used again, and it was sufficiently wealthy to expend three…of these bombs and nearly a hundred ships in the most costly and elaborate weapons tests performed on earth up to that time.[28]

Such a proportionately large expenditure of the nuclear arsenal was only imaginable while that arsenal remained small and tensions with the Soviet Union relatively low – both circumstances unique to the immediate post-war years. But one should not forget that CROSSROADS was held a year before the Atomic Energy Act

[25] See particularly David Alan Rosenberg, "U.S. Nuclear Stockpile, 1945 to 1950," *The Bulletin of the Atomic Scientists* 38 May 1982); Rosenberg, "The Origins of Overkill: Nuclear Weapons and American Strategy, 1945-1960."

[26] Weisgall, *Operation Crossroads: The Atomic Tests at Bikini Atoll*: 9.

[27] Rosenberg, "The Origins of Overkill: Nuclear Weapons and American Strategy, 1945-1960," 14. For details of the cancellation of CHARLIE see Chapter One of this thesis.

[28] Delgado, "The Archaeology of the Atomic Bomb: A Submerged Cultural Resources Assessment of the Sunken Fleet of Operation Crossroads at Bikini and Kwajalein Atoll Lagoons," 15. It would seem from these comments alone that Delgado perceives CROSSROADS to have served diplomatic ends.

and the creation of the Atomic Energy Commission; the U.S. military, divided as it then was, controlled the stockpile and organised the tests. That military presumably expected something to justify the expenditure of a third of the stockpile. Here it is easy to turn to "atomic diplomacy" as the solution, but more likely was that CROSSROADS was the first weapons effects test series – a form of nuclear testing the produced important data relating to the use and effectiveness of nuclear weapons, and which until 1963 remained the purview of the Department of Defense.[29] CROSSROADS was the first opportunity for the U.S. military to acquire this information (as its measurement was lacking entirely from TRINITY, Hiroshima and Nagasaki), and was likely invaluable for military plans for the use of atomic weapons.[30]

If the establishment of precedents goes some way to the emergence of a norm, then Operation CROSSROADS was the most crucial test series for the normalisation of nuclear weapons testing. With CROSSROADS, it became acceptable behaviour for the United States to detonate nuclear weapons during peacetime for the purposes of studying their military effects rather than *exclusively* proving their function; use the remote Pacific islands and atolls to protect its population from radiation; conduct

[29] *The New York Times*, citing the Federation of American Scientists, reported on 26 May 1946 that the "tests were purely military, not scientific…Scientists expect nothing of scientific value and little of technical value to peacetime uses of atomic energy." Quoted in Weisgall, *Operation Crossroads: The Atomic Tests at Bikini Atoll*: 97. The focus on weapons effects rather than weapons development "disappointed" many Los Alamos scientists. Ibid., 135.

[30] Rosenberg also notes that the final report of the JCS Evaluation Board of the CROSSROADS series, completed in 1947, "recommended that Congress…redefine 'acts of aggression' to include 'the readying of atomic weapons against us,' and to authorize the President, 'after consultation with the Cabinet, to order atomic bomb retaliation' to prevent attack on the U.S." Rosenberg, "The Origins of Overkill: Nuclear Weapons and American Strategy, 1945-1960," 17. The results of the Bikini tests together with this recommendation from the JCS may have given military planners greater flexibility in drafting war plans.

these tests against a background of international and domestic opposition, and while negotiating on the international stage for control of nuclear weapons and eventual disarmament. With the implicit though likely unintentional rejection of the Baruch Plan, CROSSROADS helped normalise the possession of nuclear weapons and normalise their testing. CROSSROADS also established the form and character of subsequent test series, such as the creation of an overseeing task force and the detonation of multiple devices in compressed time and space. Indeed, the JCS Evaluation Board of the Bikini tests recommended that the United States "conduct periodic weapons tests" as part of the development, manufacture and stockpile of nuclear weapons.[31] Although some aspects of CROSSROADS were unique to 1946 – such as the backdrop of the Baruch Plan, the rivalry between the service branches in the lead-up to unification, and the military as the controlling agency – much of what was established at Bikini Atoll in 1946 came to be repeated in the eighteen succeeding series held between 1946 and 1963.

When Brien McMahon (D-CT), chairman of the Senate Special Committee on Atomic Energy, wrote to Truman in February 1946 and commented that the name CROSSROADS had been "most appropriately chosen," he was touching upon something quite important although he was probably not fully aware of it.[32] Not only was the form of the U.S. military at a crossroads, but so too was the international forum, at least in terms of the international control of atomic energy. Moreover, Operation CROSSROADS marked the intersection between a time when the testing of nuclear weapons was a wartime necessity and a different time when testing nuclear

[31] Weisgall, *Operation Crossroads: The Atomic Tests at Bikini Atoll*: 293.
[32] Senator Brien McMahon to President Harry Truman, 6 February 1946; Atomic Energy: President's Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Truman Papers, Truman Library.

weapons during peace was normalised as acceptable state behaviour, and acquired a momentum of its own. The Bikini tests were an acutely transformative experience for the U.S.; indeed, the three dimensions of CROSSROADS examined above – the negotiations for international control of atomic energy, infighting between the branches of the U.S. military, and the limitation to the nuclear stockpile – would all change before, or as a result of, the next test series: Operation SANDSTONE in 1948.[33]

Weapons Development

Eighty per cent of the nuclear tests conducted by the United States between 1945 and 1952 were fired for "weapons related" purposes – meaning scientific development and technical refinement of nuclear weapons.[34] This feature of testing was a natural and expected result of the technological infancy of nuclear weapons and the potential improvements visible on the theoretical horizon. Indeed, the results of these test series led to a dramatic improvement in the yield of U.S. nuclear weapons that cannot be understated: following CROSSROADS, which was conducted with unimproved devices identical to the Fat Man bomb used against Nagasaki, it took five

[33] "International control [of atomic energy] remained the only official policy enunciated by the U.S. government relative to atomic weapons through the summer of 1948." Rosenberg, "The Origins of Overkill: Nuclear Weapons and American Strategy, 1945-1960," 12. This change had less to do with SANDSTONE as it did the events of that year, described by Williamson and Rearden as a "year of crisis." See chapter four of Williamson Jr., *The Origins of U.S. Nuclear Strategy, 1945-1953*: 77-100. Service rivalry (at least, as described above) and military control of nuclear tests ended with the National Security Act and Atomic Energy Act of 1946 and 1947, which combined the Navy and War Departments into the Department of Defense and established the civilian control of nuclear weapons and their testing through the formation of the AEC.

[34] "United States Nuclear Tests: July 1945 through September 1992," 2-5. See Chapter One.

test series to lead to the first hydrogen bomb. This development represented an increase in yield of four hundred and ninety five times. With the notable exception of CROSSROADS, weapons development tests defined nuclear testing under Truman.

The first test series held after CROSSROADS was Operation SANDSTONE. SANDSTONE was carried out in April and May 1948 – the final shot of the series, SANDSTONE ZEBRA, was fired less than six weeks before the Soviets revoked land access to West Berlin, precipitating the 1948 Berlin Crisis. SANDSTONE demonstrated crucial technical developments in nuclear weapons design that in turn had profound effects upon U.S. strategy for nuclear weapons.[35] Two weapons developments deserve to be singled out: the design of a composite core – which used a mixture of plutonium and enriched uranium (uranium-235), thereby reducing the amount of scarce and expensive plutonium required in bomb design – and the design of the levitated core – which suspended the fissile core in an airspace between it and the high-explosive lens, thereby allowing the shock wave from the lens to gather momentum before imploding the fissile core. Together, these improvements greatly increased the efficiency of the nuclear chain-reaction and in turn more cost-effectively consumed the fissile material. Weapons developments resulting from SANDSTONE permitted more bombs of higher yield to be produced more cheaply – with important consequences for nuclear strategy. As Rosenberg writes, SANDSTONE promised that "the 'doctrine of scarcity' which had governed all previous planning for nuclear war might no longer apply."[36]

The SANDSTONE series demonstrated more than technical and theoretical developments. The 1948 test series showed the intimate connection between plans for

[35] See Chapter One.
[36] Rosenberg, "The Origins of Overkill: Nuclear Weapons and American Strategy, 1945-1960," 19.

the use of nuclear weapons and the size of the stockpile, and the size of the stockpile was related to developments from testing. If the United States was prepared to expend a third of its nuclear arsenal in the CROSSROADS series that was partly because in 1946 plans for the use of that arsenal were ill defined; hardened tensions had by 1948 generated detailed war plans that "expanded along with the nuclear stockpile."[37] Indeed, by the end of 1948, the war plan TROJAN envisaged the use of 133 atomic bombs against the Soviet Union – almost four times the number of weapons to be used in the BROILER war plan of the preceding year.[38]

While the weapons developments of SANDSTONE affected fission weapons – making them cheaper, more plentiful, and more effective – subsequent test series produced data relevant to the development of fusion weapons. The RANGER and GREENHOUSE series were held in 1951, following the test of the first Soviet atomic weapon in August 1949 and Truman's subsequent directive of January 1950 to begin work on the hydrogen bomb. The GEORGE shot of Operation GREENHOUSE, probably the single most important nuclear test between TRINITY and IVY MIKE, demonstrated a design that would come to be known as a boosted fission weapon. This design included a small amount of fusion fuel that imploded along with the fissile core, greatly increasing the efficiency of the reaction, and thus the yield of the device. More to the point, GREENHOUSE was a crucial step toward the hydrogen bomb, as it proved that the pressure and temperature generated by an atomic explosion were sufficient to initiate nuclear fusion.

[37] Ibid., 15.
[38] Ibid., 15-16. Rosenberg's article identifies technological change as the foremost "external dynamic" to the evolution of U.S. nuclear strategy in the early Cold War. Ibid., 10.

Operation GREENHOUSE, along with the previous RANGER series and all subsequent series through IVY, were wartime test series. On 25 June 1950, the North Korean army commenced the invasion of South Korea that began the Korean War. There would not be peace until after Truman left office. The effect that the Korean War had upon weapons development tests was not of the same profundity as that the Second World War had upon TRINITY. For example, the total secrecy of TRINITY was absent from the test series of the Korean War, which continued to be publicly announced beforehand. Nonetheless, as noted in Chapter One, the need to blockade Korea threatened to draw warships away from the task forces assigned to Pacific tests, and military personnel assigned to construct test facilities on the Pacific islands were instead to be deployed to Korea.[39] This moderated effect was likely because Korea was a far more limited conflict in scope and space than that which had preceded it.

Quite apart from revelations regarding the possible use of nuclear weapons in the Korean War – for example, General Douglas MacArthur saw the potential to interdict routes into North Korea from Manchuria and Vladivostok[40] – the weapons development tests conducted during the war are typically seen as entirely separate from that conflict. Like the Korean War itself, nuclear testing should be seen as part of the meta-conflict that was the Cold War. The weapons developed in these tests – demanded by the AEC and Department of Defense, directed by Truman, and expected by NSC-68 – were to form an arsenal to fight the Cold War and not the concurrent Korean War. This is not a novel observation. Rather, when contrasted with the previous wartime weapons development test, TRINITY, the test series held during the

[39] Rhodes, *Dark Sun: The Making of the Hydrogen Bomb*: 442. The relationship between the logistics of nuclear testing and the logistics of fighting the war in Korea was explored in Chapter One.
[40] Ibid., 444.

Korean War illustrate the shifting of norms. Immediately after the success of TRINITY, atomic weapons were moved to the front and used against Japan, but no such immediate use came from the successes of GREENHOUSE in 1951 or IVY in 1952. The norm governing the use of atomic weapons had changed: no longer was it acceptable behaviour for the United States to use these weapons in war, or at least a comparatively limited war.[41] There were many reasons for this shift – the emergence of a global competitor to Washington, which possessed its own limited nuclear arsenal; the dissimilar character and scale of the Korean War compared to the Second World War; the inability to deliver in a combat setting the prototype devices tested (like IVY MIKE); and even widespread public awareness of the horrors of atomic bombing. But one of the reasons for this changed norm came from nuclear testing itself, which provided more data and developed more powerful weapons than had been available in 1945.

While the use of nuclear weapons was constrained by the perception of their increasing destructiveness and the international political context, weapons development tests from Operation SANDSTONE onward did establish the norm of continued and deliberate improvement of nuclear weapons.[42] This may appear a

[41] Tannenwald argues that the Korean War established the normative basis of the taboo against the use of nuclear weapons. See Tannenwald, "The Nuclear Taboo: The United States and the Normative Basis of Nuclear Non-Use."

[42] Relatedly, and to risk a generalisation, for at least a hundred years wars had been fought with the weapons that emerged at the end of the previous war, improved, but only marginally. Weapons were bettered in the space between wars only in a technical and doctrinal sense – qualitative improvement, such as the leap from piston-engine to jet-engine aircraft, or from combustion-engine vehicles to tanks, came mostly through the developmental pressures of conflict. This trend vanished after the Second World War. Atomic weapons represented the forefront of many fields of science, foremost physics, and their development promised application beyond the battlefield. But most importantly these weapons represented such a tremendous growth in firepower and destructiveness that no longer could it be assured that a war fought with them would

fundamentally obvious statement to make but one must remember that for the first three years during which the United States possessed atomic weapons it made little effort to improve those weapons. From TRINITY in 1945, through CROSSROADS in 1946 and through to SANDSTONE in 1948, the U.S. possessed unimproved devices of the same type used above Nagasaki – scarce, expensive and comparable in yield.[43] This characteristic changed after 1948 and the change dramatically accelerated in 1951, following the end of the U.S. atomic monopoly, Truman's decision to pursue the hydrogen bomb, the start of the Korean War, and the appearance of NSC-68. All of these events and decisions in confluence created pressure for weapons development tests, and these tests normalised the idea that nuclear weapons could be improved just like any other weapons system.

The DESERT ROCK Exercises

While weapons development tests led to technical developments that in turn diversified and increased the size of the U.S. nuclear stockpile, the war in Korea demonstrated how ill-prepared the United States military was to engage in tactical nuclear war. This is an observation made by Tannenwald and supported by Rosenberg.[44] In the debate regarding the use of atomic weapons in Korea, at least some of those who supported such use identified the problem as not that there were too few suitable targets but rather that the United States military was itself unprepared

last long enough, or a society survive sufficiently intact while fighting it, for the kind of organic development of weapons technology that had characterised previous wars.

[43] Bernard Brodie, *Strategy in the Missile Age* (Princeton: Princeton University Press, 1959), 150-51.

[44] Tannenwald, "The Nuclear Taboo: The United States and the Normative Basis of Nuclear Non-Use," 443-51; Rosenberg, "The Origins of Overkill: Nuclear Weapons and American Strategy, 1945-1960," 11-27.

for tactical nuclear combat.[45] Specifically, “virtually no U.S. troops had been trained in using nuclear weapons on the battlefield.”[46] This observation was made to MacArthur in March 1951 and the Department of Defense responded quickly: the BUSTER-JANGLE test series of October-November 1951 included the first DESERT ROCK tactical nuclear exercises.

The DESERT ROCK exercises were a series of troop training and military exercises conducted to “test tactics and protective measures” that might be used in a tactical nuclear conflict.[47] Three exercises were held at the BUSTER-JANGLE series while a fourth was held at the succeeding TUMBLER-SNAPPER series. They involved thousands of defense personnel who attended briefings and orientation, observed nuclear tests, conducted military manoeuvres in the aftermath of the shots, inspected damage caused by the shot, and undertook post-shot surveys. The results of one such survey noted that “an important goal of the Desert Rock [sic] training maneuvers was to eliminate the exaggerated fear of atomic weapons by giving troops first-hand experience with atomic explosions.”[48]

As a method of preparing the military for the realities of tactical nuclear warfare the DESERT ROCK Exercises I through IV were successful. Troops gained an understanding of atomic explosions and their effects and were trained in radiological and blast safety measures. Moreover, the military personnel involved in the exercises showed increased confidence as the exercises progressed. Airborne personnel in DESERT ROCK I had demonstrated measurable signs of tension and

[45] Tannenwald, "The Nuclear Taboo: The United States and the Normative Basis of Nuclear Non-Use," 446.
[46] Ibid.
[47] Ponton, "Operation BUSTER-JANGLE, 1951," 46. See Chapter One of this thesis.
[48] Suzanne G. Billingsley, et. al., "Reactions of Troops in Atomic Maneuvers: Exercise DESERT ROCK IV," (Chevy Chase, Maryland: The John Hopkins University, 1953), 22.

stress, while mechanised infantry tested in DESERT ROCK IV presented fewer signs of apprehension.[49] The report on the exercises notes that this discrepancy may have resulted from the fact that DESERT ROCK I was "the first use of troops in an atomic maneuver and participation was perhaps a more stressful experience than in subsequent exercises."[50] Nonetheless, using a nuclear test to expose military personnel to the atomic bomb within a tactical context appears to have gone some way toward preparing the U.S. military doctrinally and the U.S. soldier psychologically for tactical nuclear warfare.

It is of particular note that these exercises commenced in 1951. This thesis accepts that the DESERT ROCK exercises were a deliberate response to the Korean experience, but it also worth considering another approach. Frank Kofsky and Dominic Cerri have argued that the Truman Administration used "well-worn methods of artifice" to generate a "war scare" in the spring of 1951.[51] These authors suggest that the Truman Administration used misleading statements and inflated threats in an attempt to "overcome congressional resistance to the stupendous military buildup it began once the Korean War furnished a suitable pretext," just as it had in 1948.[52] Much of the planning for Operation BUSTER-JANGLE, at which Exercises DESERT ROCK I through III were held, took place in spring of 1951 during the height of this manufactured war scare. These exercises received "considerable publicity" and were perceived to have "significant propaganda effect upon our potential enemies" while

[49] Ibid., 20. These physiological signs were measured by taking the blood pressure of participants and subjecting them to polygraph surveys.
[50] Ibid.
[51] Kofsky, "Truman and the 1951 War Scare."
[52] Ibid.

the "psychological effect upon our own civilian population may also be important."[53] It is curious timing indeed that so demonstrative a test series should be planned during a period when the administration had deliberately escalated its rhetoric, although this connection remains an entirely speculative one. The DESERT ROCK exercises began about as early as they could: the Nevada test site was opened with the RANGER series in early 1951, and the islands that bore the Pacific tests before then lacked the geography for military exercises. It is nonetheless worthwhile to consider that DESERT ROCK responded to domestic pressures beyond those coming from a military fighting in Korea.

If nothing else, the DESERT ROCK exercises offer a very visible indication of when the United States began to consider tactical nuclear warfare possible. While the nuclear stockpile was small, those scarce weapons would not be used against tactical targets. But that stockpile had changed by 1951: Truman had approved a substantial increase in nuclear production in 1949 and another increase in 1950.[54] These increases combined with the technical improvement in weapons design accomplished in the SANDSTONE tests of 1948 led to an expansion of the stockpile sufficient to seriously entertain concepts of tactical use. At the same time, the experiences of the Korean War stressed a need for further thought, experimentation and training in the tactical use of nuclear weapons. The DESERT ROCK exercises of

[53] Billingsley, "Reactions of Troops in Atomic Maneuvers: Exercise DESERT ROCK IV," 23.

[54] The increase of 1949 coincided with Truman's opinion that "we'll never obtain international control." Rosenberg, "The Origins of Overkill: Nuclear Weapons and American Strategy, 1945-1960," 21-22.

the BUSTER-JANGLE and TUMBLER-SNAPPER tests series both responded to and exemplified this need.[55]

The Hydrogen Bomb Decision

The debate within the Truman Administration that took place in the winter of 1949-1950 regarding the hydrogen bomb was probably one of the most important in modern history. Brien McMahon, chairman of the Joint Committee on Atomic Energy (JCAE), wrote to Truman as part of this debate and supposed that "the profundity of the atomic crisis which has now overtaken us cannot…be exaggerated."[56] Joseph M. Siracusa has described the decision that resulted from this debate as "a watershed moment."[57] Analysis of the decision to pursue thermonuclear weapons is extensive.[58] Missing from this discourse is an appreciation of the hydrogen bomb decision as a

[55] Impressive though the DESERT ROCK exercises were, they paled in comparison to the scale of later Soviet tactical nuclear exercises. David Holloway describes an exercise near Totskoe in the winter of 1953-54 in which an astonishing 44,000 troops took part. A "medium-yield" atomic bomb was dropped on a target surrounded by equipment, instruments and animals; the troops then fought a mock-battle over the area. Veterans of the battle of Berlin in 1945 said that "they had not seen anything like [the Totskoe exercise]." Holloway, *Stalin and the Bomb: The Soviet Union and Atomic Energy 1939-1956*: 326-27.

[56] Letter from Brien McMahon to President Truman, 21 November 1949; Subject File, Arabian Relations [December 10, 1947] to Council of Foreign Ministers – November-December 1947, Box 10; Subject File; SMOF: Naval Aide to the President Files, 1945-1953; Papers of Harry S. Truman, Truman Library.

[57] Siracusa, *Nuclear Weapons: A Very Short Introduction*: 53.

[58] For the connection between NSC-68 and the hydrogen bomb decision, see Siracusa, "NSC 68 and the H-Bomb Decision." For the role of the U.S. military in the decision, see Rosenberg, "American Atomic Strategy and the Hydrogen Bomb Decision." For efforts to halt the first test of the hydrogen bomb and domestic pressures to test, see Bernstein, "Crossing the Rubicon: A Missed Opportunity to Stop the H-Bomb?" For the technical development of the hydrogen bomb, see Rhodes, *Dark Sun: The Making of the Hydrogen Bomb*.

normative construct, one that further normalised – indeed, hinted at the future expansion of – possession and testing of nuclear weapons.

The debate regarding the hydrogen bomb was sparked by the Soviet nuclear test of 29 August 1949, which broke the United States' atomic monopoly. Supporting the development of "supers" were the AEC and Department of Defense, along with McMahon and the JCAE. Opposing them were a handful of nuclear scientists, mostly in the General Advisory Committee of the AEC and the State Department's Panel of Consultants on Disarmament. Foremost among these were Oppenheimer, Enrico Fermi, I.I. Rabi – who called the hydrogen bomb "evil" – and Vannevar Bush, who had been Roosevelt's chief science advisor during the war.[59] As with CROSSROADS in 1946, here again a minority of scientists were opposed to nuclear testing; this panel of scientists was without political allies, and public opposition was this time precluded by the secrecy of the debate.

Without actually knowing it, the advocates of a crash program for the "super" were generating normative paradigms. Here I mean both the normalisation of possession and testing, this time of thermonuclear weapons, but also the broadening of an emergent concept that nuclear weapons were normative symbols of a state's identity. The hydrogen bomb represented the hopes of its supporters that the United States could recapture that technological supremacy it had lost once the atomic monopoly was broken.

Lewis Strauss, who would become chairman of the AEC under Eisenhower but who wrote to Truman in 1949 as a commissioner of that body, identified a number

[59] Bernstein, "Crossing the Rubicon: A Missed Opportunity to Stop the H-Bomb?" 135. Bush was the driving force behind a proposal to ban tests of hydrogen bombs, or to at least delay the first test until Eisenhower took office. His efforts in this respect are detailed in Chapter Three.

of arguments that must have been striking to the president. Some of these arguments were particularly weak – for example, that "a government of atheists is not likely to be dissuaded from producing the weapon on 'moral' grounds" – but at least one suggested that the hydrogen bomb might be used tactically.[60] "Unlike the atomic bomb," Strauss wrote, "which has certain limitations, the proposed weapons may be tactically employed against a mobilized army over an area of the size ordinarily occupied by such a force."[61] This must have been appealing to Truman and the JCS, as the atomic stockpile was in 1949 still too small and the individual weapons too bulky and limited in power for use against mobile targets, such as an army, to be "seriously considered."[62] Here Strauss was normalising the idea that the hydrogen bomb could serve a purpose that the atomic bomb had yet to fulfil. Indeed, in his letter to Truman, Strauss even suggests that the hydrogen bomb could be used by the United States on its own territory: "the weapon may be critically useful against a large enemy force both as a weapon of offense and as a defensive measure to prevent landings on our own shores."[63] This last was a particularly hazardous notion to normalise, and one that clearly predates the CASTLE BRAVO test of 1954 and awareness of the immense radiological dangers of thermonuclear weapons.

The contest over those radiological dangers – fallout – represented another dimension to the theme of normalisation employed by advocates of the "super." Strauss's letter to Truman rejects a letter from the AEC dated just two weeks earlier that detailed serious concerns about the radioactivity and pollution caused by testing

[60] Letter from Lewis Strauss to President Truman, 25 November 1949; Subject File, Arabian Relations [December 10, 1947] to Council of Foreign Ministers – November-December 1947, Box 10; Subject File; SMOF: Naval Aide to the President Files, 1945-1953; Papers of Harry S. Truman, Truman Library.
[61] Ibid.
[62] Rosenberg, "American Atomic Strategy and the Hydrogen Bomb Decision," 74.
[63] Ibid.

of hydrogen weapons. Strauss wrote that new calculations had shown that it would instead require “many hundreds” of detonations to “pollute the earth’s atmosphere.”[64] Strauss was presumably referring to data that was sent to Truman by Sumner Pike, at that time the acting chairman of the AEC, almost two weeks later.[65] Pike concluded that if all the devices were set off “in a period of a few weeks,” about 500 hydrogen bombs would pollute the atmosphere with radioactive carbon, but if the devices were detonated at a pace similar to previous nuclear tests “about 50,000 super bombs would be necessary to build up dangerous effects.”[66] The image that Pike’s words convey – the relatively safe testing of tens of thousands of hydrogen bombs – is a stupefying one and one that goes some way to normalising the act of testing a handful of such devices. By contrast, Pike’s words imply that the modest number of tests necessary to develop thermonuclear weapons were a completely rational and even safe action, and thus constituted acceptable behaviour for the United States. Arguments such as these from advocates of the “super” went a long way to normalising the act of nuclear testing.

While it appears to have been assumed during the debate of 1949-1950 that the United States would stockpile and thus possess the hydrogen bomb once it had been developed – many of the arguments for development used by Strauss, for

[64] Ibid.

[65] Richard Rhodes describes Pike as “a tough-minded self-made millionaire from Maine.” Rhodes, *Dark Sun*, 379.

[66] The Effect of Radioactive Carbon from Thermonuclear Bombs, Letter from Sumner Pike to President Truman, 7 December 1949; Atomic Energy: President’s Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Papers of Harry S. Truman, Truman Library. These calculations took no account of local fallout – dramatically observed at the CASTLE BRAVO test in 1954 – or of the use of a uranium tamper to surround the thermonuclear device – which would become an issue with the Soviet test of 30 October 1961. See Chapters Three and Six.

example, outline the benefits of possession to the United States – that particular question was itself poorly articulated. The recommendation that Truman signed on 31 January 1950, which represented the final decision, was also noteworthy for posing just this problem:

> It must be considered whether a decision to proceed with a program directed toward determining feasibility [of the hydrogen bomb] prejudges the more fundamental decisions (a) as to whether, in the event that a test of a thermonuclear weapon proves successful, such weapons should be stockpiled, or (b) if stockpiled, the conditions under which they might be used in war.[67]

Both questions were addressed by one of the most important documents of the Cold War: NSC-68, which resulted from Truman's directive to secretary of state Dean Acheson and secretary of defense Louis Johnson to reassess the threat from the Soviet Union.[68] NSC-68 reiterated these two questions as its terms of reference.[69] This preamble included the cogent recognition that "if a test of a thermonuclear weapon proves successful, the pressures to produce and stockpile such weapons…will be greatly increased."[70] Such technological determinism was plainly seen after TRINITY in 1945 and SANDSTONE in 1948. But NSC-68 went further – it recommended production and stockpiling of thermonuclear weapons "in the event they prove feasible" and noted also that such weapons would "add significantly to our net

[67] Terms of Reference, 29 March 1950; Atomic Energy: President's Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Papers of Harry S. Truman, Truman Library.
[68] This directive to Acheson and Johnson was made on the same day as Truman's decision to begin a crash program to develop thermonuclear weapons.
[69] For a complete copy of this document, see Appendix 4: NSC-68: United States Objectives and Programs for National Security (April 14, 1950) in Joseph M. Siracusa, *Into the Dark House: American Diplomacy and the Ideological Origins of the Cold War* (Claremont: Regina Books, 1998), 211-63.
[70] Terms of Reference, 29 March 1950; Atomic Energy: President's Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Papers of Harry S. Truman, Truman Library.

capability."[71] But while speculating on the spectrum of Soviet aggressive actions, NSC-68 did not answer the second question, instead hedging with the comment "not enough is known of their [thermonuclear weapons'] potentialities to warrant a judgement at this time regarding their use in war."[72]

The hydrogen bomb decision and NSC-68 were deeply connected to the phenomenon of nuclear testing. Both were driven by the Soviet test of August 1949, and both drove U.S. policy toward tests of hydrogen bombs. The first Soviet nuclear test propelled the United States' nuclear program and thus further U.S. testing, just as Hiroshima and Nagasaki had propelled the Soviet nuclear program.[73] These were the earliest examples of the political implications of nuclear weapons tests that would be seen again in the case of China, India and Pakistan – where a nuclear test demonstrates proof of possession as much as proof of concept, requiring a response from threatened neighbours.[74] In the case of the decision by the United States to pursue and develop the hydrogen bomb, this threat was an inflated one but one that struck at a normative sense of its state identity. Moreover, both the hydrogen bomb decision and NSC-68 normalised, in the early months of 1950 and over two years before Operation IVY, the idea that thermonuclear weapons could be tested and afterwards stockpiled by the United States.

[71] Siracusa, *Into the Dark House: American Diplomacy and the Ideological Origins of the Cold War*: 241.
[72] Ibid.
[73] For the best account of the Soviet nuclear weapons program, see Holloway, *Stalin and the Bomb: The Soviet Union and Atomic Energy 1939-1956*.
[74] An exception to this idea is the example of Israel, which has thus far avoided the proof of possession that might inspire its neighbours to develop nuclear weapons. See Michael Karpin, *The Bomb in the Basement: How Israel Went Nuclear And What That Means For The World* (New York: Simon & Schuster, 2006).

Conclusion

The six nuclear test series conducted between June 1946 and June 1952 by the Truman Administration were deeply important aspects of the early Cold War. Foremost, they led through a series of important technological and theoretical developments to the hydrogen bomb – which was first tested in November 1952 during the week of the presidential election that brought Dwight D. Eisenhower to office. These series also multiplied the potential uses of the United States' nuclear stockpile, first, through the expansion of that stockpile which affected plans for its use, and, second, through the experience and training the DESERT ROCK exercises provided in tactical nuclear warfare. Additionally, these test series were by themselves important events of the early Cold War that shaped its character, none more so that Operation CROSSROADS. Finally, it was through these six series that the act of nuclear testing was normalised under Truman.

There were two, related dimensions to the process of normalisation: the first, far clearer and more observable, was the setting of precedents, whereby atmospheric nuclear tests became an established policy; the second was less distinct, and involved the gradual alignment of nuclear weapons and their testing with a normative perception of American identity. Together, these two dimensions had the effect of generating acceptance of nuclear testing as rational state behaviour.

Why does normalisation matter? The process – if it can be called that – of normalisation is historically significant, because it created the circumstances for the testing of more and larger devices during the general expansion of nuclear testing under Eisenhower. Through that process, nuclear tests became an accepted part of contemporary society. While nuclear testing was novel, it was opposed, as was the case with Operation CROSSROADS. But that series was held in spite of widespread opposition, much of it from the public, and this fact helped to normalise subsequent testing, because it demonstrated that nuclear tests would be conducted even without universal support. The test series held after 1946 did not again endure the kind of grassroots opposition that CROSSROADS had faced – it would take something profoundly outside the norm to mobilise that domestic opposition again. That change came in 1954 with CASTLE BRAVO, after which the norm began to change. Furthermore, that Washington carried out CROSSROADS against the background of the Baruch Plan and negotiations for the international control of atomic energy implied that the possession and testing of nuclear weapons was more important to the United States than an international agreement. These implied priorities further crystallised the norm of nuclear testing.

Nuclear testing noticeably accelerated as the Cold War grew more tense. Only three individual tests had been conducted between July 1945 and April 1948. In 1948, the year described by Williamson and Rearden as the "year of crisis" that included the blockade of Berlin, a further three tests were held. In 1951, the year that Kofsky and Cerri argue saw a theatrical war scare from the Truman Administration, a total of sixteen nuclear tests were conducted. In 1952, ten nuclear tests were carried out, including the first hydrogen bomb. Although this acceleration was connected to domestic and technical factors, such as evolving strategy and weapons design, it was also connected to a less-tangible factor. As the United States had demobilised and relations with the Soviet Union became slowly embittered, an awareness emerged that because of its conventional inferiority the United States had to quite rationally play to its strengths and include nuclear weapons more and more comprehensively into its sense of identity. This is an idea closely related to one of the reasons Scott Sagan uses to explain why states develop nuclear weapons: the norms model, where nuclear weapons are symbols that reflect state identity. As nuclear testing continued to establish the precedent for and normalise the possession of nuclear weapons, so too did the United States increasingly perceive their possession as a guarantor of peace, as a means of victory should peace fail, and as "normal." Following this line of reasoning, the very act of nuclear testing – separated from its results and accomplishments – had a normative effect upon U.S. nuclear strategy, because it helped establish possession and testing as acceptable state actions.

Almost all of the dimensions of testing under Truman explored in this chapter were borne out in the IVY MIKE shot of 1 November 1952. Testing had by then been normalised to such an extent that the character of that activity could be massively expanded to include atmospheric tests of multi-megaton thermonuclear weapons. The most effective and broad resistance since Operation CROSSROADS was brought to bear against the IVY series, including efforts by Vannevar Bush toward a ban of thermonuclear tests, but the series nonetheless went ahead.[75] Finally, IVY MIKE was the expected result both of the hydrogen bomb decision of January 1950 and of all the weapons developments achieved through testing that led to that decision. Chapter Three will explore the expansion of nuclear testing under Eisenhower, and I begin with the Operation IVY series.

[75] Bush's efforts are detailed in Chapter Three.

Chapter Three

Eisenhower, 1952-1958

"The sun rises in the west."

Crewmember of the *Lucky Dragon 5* regarding the CASTLE BRAVO shot, 1 March 1954.

"Why is it necessary to have so many shots? Could the series not be limited to not over twelve or so? The danger is that these tests will continue for a longer and longer period of time."

President Eisenhower regarding Operation HARDTACK Phase I, 9 August 1957.

Ten test series containing some 150 test shots were held by the United States between November 1952 and October 1958. Included among this number were the largest nuclear tests ever conducted by the United States. These years were something of a high-water mark for U.S. nuclear testing, involving extensive series in numerous environments. Thermonuclear weapons were successfully developed because of these test series and important effects of underground, underwater and high-altitude nuclear explosions were examined. Despite the success of these test series – perhaps even because of it – nuclear testing during the Eisenhower years ended with a voluntary moratorium.

Compared to testing under Truman, the test series conducted under Eisenhower were far more varied in yield and number. Certainly, these latter series were driven by more complex goals, requiring more diverse testing environments and objectives – but this variety might also speak to the concurrent efforts toward a test ban. While the trend of testing under Truman was generally upward in both yield and number of shots, this tendency was repudiated almost entirely after Operation CASTLE. Indeed, under Truman nuclear testing was normalised; under Eisenhower, it was abandoned.

The test series held under Eisenhower were part of the structure of an established Cold War. Rivalry with the Soviet Union was the fundamental aspect of nuclear testing, and the development of weapons and their delivery systems were important objectives. Early test series of the Eisenhower years took place in context of Moscow's potential lead in dry thermonuclear weapons; latter series took place in context of the Soviet lead in the space race and development of intercontinental ballistic missiles demonstrated by Sputnik in October 1957.

More than was the case under Truman, individuals stand out in the shaping of U.S. test series between 1952 and 1958. Foremost among these is Lewis L. Strauss, who replaced Gordon Dean as chairman of the Atomic Energy Commission but was also the president's advisor on matters of atomic energy. Strauss, as both Robert Divine and Benjamin Greene note, dominated Eisenhower's perspective on nuclear testing by filtering the information the president received and thus sheltering him from viewpoints opposed to Strauss's own enthusiasm for testing.[1] Strauss's influence

[1] Lewis L. Strauss enjoyed a close relationship with Eisenhower. Many of his memoranda to the president also shared their interest in livestock, and their letters continued after both left office. He was also awarded the Presidential Medal of Freedom by Eisenhower. But Strauss was most responsible for the Oppenheimer security clearance hearings, which contrasted dramatically with Gordon Dean's defense of Oppenheimer. Strauss was not above using the FBI to investigate scientists with whom he disagreed, as he did with Hans Bethe. Divine described him as "pompous, shrewd, patriotic but often mean, petty and unpredictable." Greene ascribed to Strauss "excessive secrecy, deviousness, and self-righteousness." Strauss became Chairman of the AEC on 2 July 1953. Divine, *Blowing on the Wind: The*

waned in 1957 when the controversy surrounding Sputnik and the evident Soviet lead in rocketry led to the creation of the President's Science Advisory Committee, headed by the special advisor for science and technology, James Killian. Strauss eventually resigned as chairman of the Atomic Energy Commission in June 1958.

This chapter will examine the nuclear tests series conducted by the United States between 1952 and 1958. Ten test series will be explored: IVY, UPSHOT-KNOTHOLE, CASTLE, TEAPOT, WIGWAM, REDWING, PLUMBBOB, HARDTACK I, ARGUS and HARDTACK II. These series began with the first thermonuclear test and ended with urgency before the test moratorium took effect at the end of October 1958. Analysis of these series offers momentary but recurring glimpses of Eisenhower's reluctance to test that was borne out in test ban negotiation and culminated in the test moratorium. This history of important shots and critical dimensions of each series will also contextualise the analysis within Chapter Four.

IVY

On 1 November 1952, the United States tested its first thermonuclear device as the MIKE shot of Operation IVY. IVY was a two-shot series held at Eniwetok Atoll in the Pacific Proving Ground. The timing of IVY was awkward because, on 4 November, Dwight D. Eisenhower won the 1952 presidential election in a landslide, becoming president-elect of the United States of America between the MIKE and KING shots.[2]

Nuclear Test Ban Debate, 1954-1960: 11; Greene, *Eisenhower, Science Advice, and the Nuclear Test Ban Debate, 1945-1963*: 28. For a biography of Strauss, see Richard Pfau, *No Sacrifice Too Great: The Life of Lewis L. Strauss* (Charlottesville: University Press of Virginia, 1984).

[2] IVY has been included in the chapter dedicated to testing under Eisenhower for two reasons: first, although the result of directives and decisions of the Truman

The significance of conducting so important a test series at the cusp of transition between administrations was not lost upon Truman or the National Security Council (NSC). Almost two months before IVY, Truman, via the acting executive secretary of the NSC, S. Everett Gleason, communicated his wish to Robert A. Lovett and Gordon Dean that the first shot of IVY be fired no earlier than 5 November.[3] Although he did not state it explicitly, Truman was saying that he did not want the thermonuclear test conducted until after the election of 4 November.[4] Both the secretary of defense and the chairman of the Atomic Energy Commission (AEC) reminded the president of the considerations of weather in the choice of the test date (although Gordon Dean "gave less weight to the weather factor than had Secretary Lovett"); despite this, Truman and Lovett decided to postpone the test until after the election.[5] It is unclear from the archival sources why, following this decision, the IVY series commenced before the election, although it seems likely that weather at the test site was the deciding factor. Truman, Lovett and Dean decided to resubmit the request for presidential approval for Operation IVY without any reference to date, and this appears to have been done – Gordon Dean's request of 15 August mentioned "early

Administration, the results and consequences of IVY were experienced by the Eisenhower Administration; and, secondly, the technical division between fission and fusion tests marked by IVY closely matches the discursive division between Truman and Eisenhower Administrations marked by the election.

[3] Memorandum for the Executive Secretary from S. Everett Gleason, 10 September 1952; Executive Secretary's Subject File Series, Box 4; National Security Council Staff: Papers, 1948-1961; White House Office; Dwight D. Eisenhower Library.

[4] Barton Bernstein ventures that "Truman himself wanted to delay the detonation until after election day to keep the thermonuclear issue out of partisan politics." Bernstein, "Crossing the Rubicon: A Missed Opportunity to Stop the H-Bomb?" 149.

[5] Ibid.

November" as the proposed date for IVY, while the approval signed by Truman on 10 September entirely omitted mention of proposed dates.[6]

Vannevar Bush, that wartime luminary of science administration, clearly stated his unease with the proposed date to Dean Acheson:

> I felt that it was totally improper…for that [test] to be [conducted] just before [the] election, to confront an incoming President with an accomplished test for which he would carry the full responsibility thereafter. For that test marked our entry into a very disagreeable type of world.[7]

One wonders, then, at the motivation behind Truman's unease with the target date. Barton Bernstein argues that Truman wished to keep the test away from the partisan politics of the election. It is likely that he had also hoped with some futility that the Democratic candidate, Adlai Stevenson, would win the election. Yet, Bush's criticism would still have been valid even had Stevenson won. Added to the discourse were the opinions of Panel of Consultants on Disarmament, of which Bush was a member, who argued that IVY be postponed for two reasons: to allow a new Administration to consider a test ban, and to prevent the Soviet Union from analysing – and benefitting from that analysis – the global fallout that MIKE would produce.[8]

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[6] Regarding the resubmission of request for approval: ibid. Regarding the original request for approval for Operation IVY: Memorandum for the Special Committee of the National Security Council for Atomic Energy Matters from Gordon Dean, 15 August 1952; Executive Secretary's Subject File Series, Box 4; National Security Council Staff: Papers, 1948-1961; White House Office; Dwight D. Eisenhower Library. Regarding the revised approval: Memorandum for the President from James S. Lay, Jr., 10 September 1952; Atomic Energy: President's Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Papers of Harry S. Truman, Truman Library.

[7] Quoted in Rhodes, *Dark Sun: The Making of the Hydrogen Bomb*: 497. Bush also suggested that IVY be postponed so as to pursue a test ban with the Soviet Union, presumably as a member of the Panel on Disarmament.

[8] The Panel on Disarmament was formed by Dean Acheson and included, alongside Vannevar Bush, J. Robert Oppenheimer and Allen Dulles, deputy director of the CIA. The Panel's executive secretary was a young McGeorge Bundy. Bernstein, "Crossing the Rubicon: A Missed Opportunity to Stop the H-Bomb?," 140-43.

The debate about the timing of IVY illustrates an awkward but curious paradox: if anything, Truman, Lovett and Dean needed to advance the date of IVY rather than postpone it, because the pressures of the Cold War and the fear that the Soviet Union might soon test a hydrogen bomb meant that IVY could not be postponed until the spring of 1953 (allowing time for an incoming president to consider the test series); but, as reliant as IVY was upon preceding test series, it could not be realistically advanced for technical and theoretical reasons. Bush later lamented in 1954 that "the entire program for building an H-bomb was so vigorously under way that any suggestion of delay received practically no consideration whatsoever."[9]

MIKE was detonated on 1 November 1952 on Eluklab Island at Eniwetok Atoll.[10] The test was of an experimental thermonuclear device and a substantial portion of its yield was derived by the fusion of hydrogen atoms.[11] Because of the novelty of the test, it was difficult for designers to estimate a yield for the MIKE device, and estimates ranged from four to ten megatons.[12] In fact, IVY MIKE yielded 10.4 megatons of TNT equivalent, or 10,400 kilotons, almost 750 times the yield of the bomb that destroyed Hiroshima.[13] Over three quarters of its yield, probably eight megatons, resulted from the fission of the uranium pusher that surrounded the liquid

[9] Ibid., 158.
[10] Because the test was held in the Marshall Islands, it was still 31 October in the continental United States, and the Department of Energy thus records the test date as such. "United States Nuclear Tests: July 1945 through September 1992," 4.
[11] Rhodes' work contains an entire chapter dedicated to the IVY MIKE shot, including a fascinating millisecond-by-millisecond description of the detonation. See Chapter 24 of Rhodes, *Dark Sun: The Making of the Hydrogen Bomb*: 482-512.
[12] F.R. Gladeck, et al., "Operation IVY: 1952," in *United States Atmospheric Nuclear Weapons Tests Nuclear Test Personnel Review* (Washington, D.C.: Defense Nuclear Agency, 1982), 18.
[13] "United States Nuclear Tests: July 1945 through September 1992," 4-5.

deuterium fusion fuel; MIKE was thus, in the words of Rhodes, "less a thermonuclear than a big, dirty fission bomb."[14] At the last moment before the test, the proportion of enriched uranium to plutonium in the MIKE device was increased "to secure substantially less probability of failure."[15]

MIKE produced a tremendous fireball, three miles (4.8 kilometres) across. A heat wave was felt on task force ships positioned thirty to thirty-five miles (48 to 56 kilometres) out to sea. The fireball "appeared on the horizon like a half-risen sun, quickly expanded after a momentary hover time"; a conventional but enormous mushroom cloud soon appeared, "balanced on a wide, dirty stem."[16] That stem was darkened by debris, coral particles and water, vaporised and sucked by convection high into the air. Around the base of that stem a curtain of water appeared, and slowly dropped back to the atoll surface.

As the mushroom cloud rolled upwards, it darkened from a white to a red-brown colour. Thirty minutes after the detonation, the upper cloud was sixty miles (96 kilometres) in diameter, and the stem twenty miles (32 kilometres) in diameter. The upward motion of the mushroom cloud soon, in the words of an observer, "splashed against the tropopause," and stabilised at an altitude of over 120,000 feet (36.3

[14] Rhodes, *Dark Sun: The Making of the Hydrogen Bomb*: 510.

[15] Memorandum for James S. Lay, Executive Secretary National Security Council from Gordon Dean, 30 October 1952; Atomic Energy: President's Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Papers of Harry S. Truman, Truman Library. Astoundingly, this memorandum has been annotated, presumably by a censor, with the comment "this word should have been deleted, it's more significant than the %" and an arrow drawn to the word "increase" in the sentence "an increase of oralloy (93.5% enriched) is now considered required." Oralloy was a codename given to enriched uranium during the Manhattan Project.

[16] Gladeck, "Operation IVY: 1952," 187.

kilometres).[17] By comparison, modern, commercial passenger aircraft cruise at an altitude of 37,000 feet (11.2 kilometres).

At it farthest extent, the MIKE mushroom cloud formed a canopy a hundred miles (160 kilometres) wide that shrouded the atoll; radioactive mud and heavy rain fell from this canopy, irradiating at least one of the post-detonation helicopter surveys. A photo aircraft was contaminated an hour and a half after the detonation when it flew through a cloud of fallout with some radioactive particles as large as split peas.[18]

After MIKE's detonation, the island of Eluklab vanished. The fireball vaporised the island, lifting into the air tens of millions of tons of solid matter, the lightest of which would drift down as fallout across the planet. In the place of Eluklab was a crater two hundred feet (60 metres) deep and about 6,300 feet (1.9 kilometres) across – deep enough to contain fourteen buildings the size of the Pentagon.[19] The bodies of birds were infrequently found, others found alive but sick and with singed feathers and unable to fly; more often, birds scattered by the flash were burned to cinders in mid air. Fish were found on the island of Engebi, three miles (4.8 kilometres) from ground zero, with skin missing or charred on one side as though they "had been dropped in a hot pan."[20] They had presumably been washed up by the three-foot (1 meter) wave that had rushed across the atoll in the thirty minutes after the detonation.[21]

In the shadow of that vast and – in the truest sense of the word – awesome mushroom cloud, MIKE was marred by what appears to have been the first direct

[17] Ibid., 188. These figures were later questioned but revised figures are not available.
[18] Ibid., 191.
[19] Ibid., 188.
[20] Rhodes, *Dark Sun: The Making of the Hydrogen Bomb*: 509-10.
[21] Gladeck, "Operation IVY: 1952," 188.

fatality associated with U.S. nuclear testing.[22] The height of the bomb cloud necessitated the use of jet sampler aircraft (rather than propeller-driven types like the B-17 and B-50 used at earlier series), and F-84G fighter-bombers were used at IVY. Two of these sampler aircraft, Pebble Red 3 and 4, were unable to refuel from an aerial tanker, and were diverted to Eniwetok airstrip for emergency landing. Red 3 successfully landed, but Pebble Red 4 splashed down in the water 3.4 miles (6.3 kilometres) from the airstrip. A search-and-rescue helicopter arrived over the crashed aircraft: it had flipped over on impact and begun to sink, and the pilot was never found.[23]

The second shot of IVY, KING, was detonated two weeks later. The KING shot was an airdrop test of "a stockpile weapon modified to produce a large yield."[24] It remains unclear what modifications were involved, although, given the results of GREENHOUSE and the yield of KING, it seems likely that this device was boosted through the inclusion of some amount of fusion fuel. KING yielded 500 kilotons, more than twice the yield of GREENHOUSE GEORGE and thirty-five times the yield of the Hiroshima bomb.[25] The significance of KING is often lost in the shadow of the preceding MIKE; that single shot was by itself of greater yield than the combined yield of any test series that preceded it. But KING was the largest fission

[22] Experimental physicist Raemer Schriber described the mushroom cloud: "it was awesome. It just went on and on." Quoted in Rhodes, *Dark Sun: The Making of the Hydrogen Bomb*: 509.

[23] Gladeck, "Operation IVY: 1952," 190-91. Furthermore, at least one aircraft diverted to assist the rescue was heavily irradiated when, taking a direct path to the crash site, it flew through the worst of the fallout from the MIKE shot. The aircraft received 20-25 roentgens and its crew up to 17.8 roentgens, the highest exposure of test personnel for Operation IVY and a dosage four to five times greater than that received by the pilots who flew sampler missions through the bomb cloud.

[24] Ibid., 199.

[25] "United States Nuclear Tests: July 1945 through September 1992," 4-5.

device tested by the United States.[26] It was important in two dimensions: first, because it represented a contingency in the event that the thermonuclear experiment of MIKE was unsuccessful, and, second, because it was a test of the kind of high-yield fission devices for which opponents of the thermonuclear bomb had argued.[27]

IVY was a weapons design series, and both shots tested new weapons developments.[28] The objective of the series, as articulated to Truman, was to "produce, if possible, and study a full-scale thermonuclear reaction."[29] This objective was achieved with IVY MIKE, the culmination of debate regarding the thermonuclear bomb and Truman's decision to develop it, and culmination too of the tests, experiments and measurements of many preceding series. It was not, however, Truman but rather Eisenhower who contended with the consequences of IVY's success.

UPSHOT-KNOTHOLE

The eleven-shot Operation UPSHOT-KNOTHOLE was a combined Department of Defense and AEC test series not dissimilar from those other hyphenated test series of the Truman era, BUSTER-JANGLE and TUMBLER-SNAPPER.[30] As with those two series, UPSHOT-KNOTHOLE was an amalgamation of two separately planned series. It was held in the spring of 1953, and was the first

[26] Ibid.
[27] Gladeck, "Operation IVY: 1952," 18.
[28] Ibid, 26. Both shots are defined by the Department of Energy as "weapons related" tests. "United States Nuclear Tests: July 1945 through September 1992," 4-5.
[29] This was the first of two objectives; the second remains redacted. Memorandum for the Special Committee of the National Security Council for Atomic Energy Matters from Gordon Dean, 15 August 1952; Executive Secretary's Subject File Series, Box 4; National Security Council Staff: Papers, 1948-1961; White House Office; Dwight D. Eisenhower Library.
[30] See Chapter One.

series conducted under Eisenhower. Indeed, the AEC announced UPSHOT-KNOTHOLE less than a week after Eisenhower took office.[31]

As the first series conducted during the Eisenhower Administration, UPSHOT-KNOTHOLE offers an interesting if early glimpse at Eisenhower's opinion of nuclear testing. Most interesting is an undated (most likely from around the end of May) and handwritten note from S. Everett Gleason, deputy executive secretary of the NSC, which documented that "the President has given *a reluctant approval* to the Upshot-Knothole [sic] case presented by [Lewis] Strauss."[32] This reluctance extended also to witnessing the tests themselves. Val Peterson, the acting administrator of the Federal Civil Defense Administration (FCDA), offered a "cordial invitation" to Eisenhower to observe the ANNIE shot of UPSHOT-KNOTHOLE; however, unlike the invitation for Truman to observe BUSTER-JANGLE, researchers do not have access to Eisenhower's response, if he responded at all.[33] Oddly, however, Eisenhower many years later and with some degree of mirth noted in a press conference that he had not been allowed to witness a nuclear test.[34]

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[31] AEC Announces New Series of Tests to be Conducted at Nevada, 26 January 1953; Subject Series, Box 7; White House Central Files (Confidential File); Eisenhower, Dwight D.: Records as President; Dwight D. Eisenhower Library.

[32] Admiral Strauss' Office Informs Me, undated; Executive Secretary's Subject File Series, Box 4; National Security Council Staff: Papers, 1948-1961; White House Office; Dwight D. Eisenhower Library. Emphasis my own. Lewis Strauss would replace Gordon Dean as Chairman of the AEC in July 1953 – one wonders what "case" Strauss had presented to Eisenhower at a time when Dean was Chairman. It was almost certainly that regarding the CLIMAX shot, which we shall soon explore.

[33] Val Peterson to President Eisenhower, 26 February 1953; OF108 Atomic Energy – Atomic Power, 1957, Box 450; Official File; White House Central Files; Dwight D. Eisenhower Library. Peterson also offered an invitation on behalf of himself and Gordon Dean to James Lay, Jr., the Executive Secretary of the National Security Council, to witness ANNIE. Val Peterson to Mr. James Lay, Jr., 26 February 1953; Executive Secretary's Subject File Series, Box 5; National Security Council Staff: Papers, 1948-1961; White House Office; Dwight D. Eisenhower Library.

[34] A reporter for the *New York Herald Tribune* asked "I have often wondered, have

Planning for UPSHOT-KNOTHOLE began at the end of 1951 when the Joint Chiefs of Staff considered a weapons-effects test series in 1953; the Department of Defense advised the NSC of the need to test "not more than three atomic devices" at the Nevada Test Site.[35] These tests became Operation KNOTHOLE, and were conducted "to obtain additional data on the military effects of atomic explosions and to test the projectile now being stockpiled for the 280-mm gun."[36] KNOTHOLE was combined with Operation UPSHOT, a series of weapon development tests conducted by the AEC.[37] UPSHOT was composed of "not more than eight" tests and, together with the two shots of KNOTHOLE, was approved by Eisenhower on 21 February.[38]

To these ten tests an eleventh was added while the series was underway. In April, and again in May, requests for additional expenditure of fissionable materials were submitted to Eisenhower because of the decision of the AEC to test an

you ever seen a hydrogen bomb?" to which Eisenhower replied "They won't allow me (laughter)…I have seen the bomb, I haven't seen the test…I just haven't been allowed to go to the tests." Official White House Transcript, President Eisenhower's Press and Radio Conference #161, 17 June 1959; Press Conference Series, Box 8; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library. These comments shall be further discussed later in this chapter.

[35] Memorandum for the Executive Secretary, National Security Council from William C. Foster, 22 December 1951; Atomic Energy: President's Directive [1 of 3] to Atomic Weapons: Procedure for Use, Box 176; National Security Council – Atomic File; PSF: Subject File, 1940-1953; Papers of Harry S. Truman, Truman Library.

[36] Memorandum for James S. Lay, Executive Secretary National Security Council from Gordon Dean, 16 February 1953; Executive Secretary's Subject File Series, Box 4; National Security Council Staff: Papers, 1948-1961; White House Office; Dwight D. Eisenhower Library.

[37] Ibid.

[38] Ibid and Memorandum for James S. Lay, Executive Secretary National Security Council from Gordon Dean, 19 May 1953; NSC Series, Subject Subseries, Box 1; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library. The original request of the JCS in December 1951 for three tests was astonishingly accurate, as the Department of Defense series comprised only two shots.

additional device; this request was presented to the president in terms that "successful testing of this device will probably obviate the necessity for the AEC conducting Operation DOMINO in the fall of 1953."[39] Charles E. Wilson, the secretary of defense, supported Gordon Dean's request, but did so primarily because it would preclude the conduct of DOMINO.[40] Eisenhower's approval of this additional shot was not without rebuke: Dean was advised that "the President…stated that he thought that the responsible officials should have brought this query up for consideration at a much earlier date."[41]

ANNIE, the first shot of the series, was an "open" shot, and was conducted on 17 March. ANNIE was "open" in so far as "representatives of press, radio and motion pictures" were invited to attend the test along with civil defense personnel.[42] It was the opinion of the AEC and the FCDA that those invited would be given "a better understanding of atomic weapons development and its impact" through observation of the ANNIE shot, and that "the results generally were advantageous to the public."[43] It was to this shot that Eisenhower was invited. ANNIE included effects tests on civilian structures, materials and vehicles that substantively assisted the FCDA and civil defense programs and gave "graphic information on atomic bomb effects to citizens

[39] Memorandum for James S. Lay, Executive Secretary National Security Council from Gordon Dean, 19 May 1953; NSC Series, Subject Subseries, Box 1; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.
[40] Memorandum for the Chairman, Atomic Energy Commission from James S. Lay, Jr., 27 May 1953; NSC Series, Subject Subseries, Box 1; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.
[41] Ibid.
[42] Gordon Dean to Mr. Robert Cutler, 3 February 1953; Special Assistant Series, Subject Subseries, Box 1; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.
[43] Ibid.

generally."[44] ANNIE yielded 16 kilotons of TNT equivalent.[45] If the relatively low yield of this "open" shot was intended to assuage public concern it was successful – members of the Joint Committee on Atomic Energy after witnessing ANNIE said to the press: "we were impressed by the finite…nature of a single atomic blast. The explosion…could not by itself have performed miracles."[46]

The remaining tests of UPSHOT-KNOTHOLE were conducted largely for weapons design purposes, with the exception of ENCORE, which was a Department of Defense effects test.[47] These tests varied widely in yield: RUTH and RAY yielded just 200 tons; DIXIE yielded 11 kilotons; BADGER, NANCY and ENCORE yielded 23, 24 and 27 kilotons, respectively; while HARRY and SIMON yielded 32 and 43 kilotons.[48] The major purposes of these tests were to "continue experimental study of the yield of implosion bombs"; "obtain more detailed and varied information on the behaviour of radiation implosion"; "test the boosting effect of [d]euterium in an implosion weapon"; and assist the design of the two thermonuclear devices planned for the upcoming CASTLE tests series.[49] For example, NANCY and SIMON were small devices that tested fuel assembly of the fission primary (the initial fission bomb that set off a thermonuclear reaction in a hydrogen bomb); NANCY gave a smaller

[44] Ibid and Val Peterson to President Eisenhower, 26 February 1953; OF108 Atomic Energy – Atomic Power, 1957, Box 450; Official File; White House Central Files; Dwight D. Eisenhower Library.
[45] "United States Nuclear Tests: July 1945 through September 1992," 4-5.
[46] Quoted in Jean Ponton, et al., "Operation UPSHOT-KNOTHOLE, 1953," in *United States Atmospheric Nuclear Weapons Tests Nuclear Test Personnel Review* (Washington, D.C.: Defense Nuclear Agency, 1982), 31.
[47] "United States Nuclear Tests: July 1945 through September 1992," 4-5.
[48] Ibid.
[49] Memorandum for Mr. James S. Lay, Executive Secretary National Security Council from Gordon Dean, 16 February 1953; NSC Series, Subject Subseries, Box 1; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.

than expected yield while SIMON a higher.[50] UPSHOT-KNOTHOLE was intimately connected with the thermonuclear tests of the preceding IVY and subsequent CASTLE series.

The tenth shot of the series, GRABLE, was unique among U.S. nuclear tests in that it was an operational test of the atomic projectile stockpiled for the 280-mm artillery piece.[51] This projectile was a gun-assembly device, a design whose shape and ruggedness (demonstrated by JANGLE UNCLE) inclined it to use in an artillery shell. GRABLE had a slightly higher yield than Little Boy at 15 kilotons.[52] Battalions of atomic-capable 280-mm artillery batteries were attached to U.S. divisions in Europe following this successful test.[53]

As with the two preceding test series held at the Nevada site, UPSHOT-KNOTHOLE included the fifth and largest of the DESERT ROCK exercises. DESERT ROCK V involved 18,000 troops of all three branches of the Armed

[50] There were very specific requirements for a fission primary – it must be less than 27 inches (68.5 centimetres) in diameter and posses both a high and precise yield. One can presume from their results that these two shots tested the precision of yield. Memorandum for Mr. Robert Cutler from Gordon Dean, 1 June 1953; Special Assistant Series, Subject Subseries, Box 1; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.
[51] Ibid and Ponton, "Operation UPSHOT-KNOTHOLE, 1953," 39-40.
[52] "United States Nuclear Tests: July 1945 through September 1992," 4-5.
[53] By 1954, five battalions of 280-mm atomic artillery had been deployed in Europe, one battalion for each U.S. division on the continent. By 1956, these battalions had been supplemented by Honest John atomic rocket batteries while another 280-mm battalion had been deployed in Okinawa. Department of Defense Report to National Security Council on Status of United States Military Programs as of 31 December 1954; NSC Series, Status of Projects Subseries, Box 5; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library. Michael Gordon Jackson traces the discussions within the Eisenhower Administration regarding the deployment of these battalions, especially in Korea. Michael Gordon Jackson, "Beyond Brinkmanship: Eisenhower, Nuclear War Fighting, and Korea 1953-1968," *Presidential Studies Quarterly* 35, no. 1 (2005): 63-65.

Services in observation, training exercises, and manoeuvres.[54] Observers were trained to calculate safe distances for observation of nuclear detonations, use of protective equipment, measurement of battlefield radiation, and were themselves tested for psychological reactions to the use of nuclear weapons.[55] Tactical troop manoeuvres were held at shots ANNIE, NANCY, BADGER, SIMON, ENCORE and GRABLE, including a novel helicopter-borne assault to determine the capability of helicopters to attack an objective following a nuclear detonation.[56]

The final shot of the series was, appropriately, named CLIMAX, and is remarkable both for its planning and for what its testing said about atmospheric experiments in the continental United States. CLIMAX was the aforementioned shot that was added to UPSHOT-KNOTHOLE after the series had commenced. Gordon Dean articulated the reasons for this additional shot in a memorandum that responded to Eisenhower's admonishment mentioned above. The divergent results of NANCY and SIMON had jeopardised the fission primary to be used in the upcoming CASTLE series; from this experience, a new design for a primary was produced, requiring its testing before CASTLE commenced.[57] UPSHOT CLIMAX was tested only four days after this explanation from Dean, and yielded 61 kilotons.[58] Here again entered Lewis Strauss, who in May had been offered the chairmanship of the AEC but who did not

[54] AEC Announces New Series of Tests to be Conducted at Nevada, 26 January 1953; Subject Series, Box 7; White House Central Files (Confidential File), 1953-1961; Eisenhower, Dwight D.: Records as President; Dwight D. Eisenhower Library.
[55] Ponton, "Operation UPSHOT-KNOTHOLE, 1953," 60-78.
[56] Ibid., 77. The helicopter manoeuvres were not held at GRABLE.
[57] Memorandum for Mr. Robert Cutler from Gordon Dean, 1 June 1953; Special Assistant Series, Subject Subseries, Box 1; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.
[58] "United States Nuclear Tests: July 1945 through September 1992," 4-5.

take that position until UPSHOT-KNOTHOLE had ended.[59] Strauss wrote to Eisenhower in May (as a member of the AEC and not its chairman) regarding CLIMAX and expressed his ongoing concern about testing in the continental United States. Most importantly, Strauss wrote that “I have the feeling that [the yield of 61 kilotons] is *uncomfortably near or beyond the limit of size that should be tested on the continent* and I recommend against it at this time.”[60] Here Strauss, a month before assuming the chairmanship of the AEC, enunciated a limit in yield for testing in the continental United States. Indeed, CLIMAX was the second-highest yield shot ever conducted at Nevada; only one shot held on the continent after UPSHOT-KNOTHOLE exceeded 61 kilotons.[61]

UPSHOT-KNOTHOLE, then, is important partly because it demonstrated an underlying awareness of the limits of the Nevada Test Site. Recall that the Nevada site was opened for BUSTER-JANGLE because it provided the necessary conditions for the underground and cratering shots of that series (that were originally to be held at Amchitka), but had evolved into a site of “greater convenience” than the Marshall Islands.[62] Moreover, the desert of Nevada provided better terrain for the kind of tactical manoeuvres performed in the many DESERT ROCK military exercises than

[59] Strauss became Chairman of the AEC on 2 July 1953.
[60] Memorandum for the President from Lewis L. Strauss, 25 May 1953; Special Assistant Series, Subject Subseries, Box 1; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library. Emphasis my own. While recommending against CLIMAX, Strauss noted that to conduct the test at Eniwetok rather than Nevada involved a delay of three months, which might consequently delay CASTLE.
[61] This was PLUMBBOB HOOD in 1957. "United States Nuclear Tests: July 1945 through September 1992," 8-9.
[62] Strauss wrote that “there is no question of the greater convenience of the Nevada testing ground.” Memorandum for the President from Lewis L. Strauss, 25 May 1953; Special Assistant Series, Subject Subseries, Box 1; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.

the islands of the Pacific atolls. Both the convenience and the limit to yield of the Nevada site became important in the resumption of U.S. testing after the Soviet abrogation of the test moratorium in 1961.[63]

As with RANGER, Operation UPSHOT-KNOTHOLE was a test series largely obscured by the two series that bracketed it, despite its close developmental connection to both. It saw important progress in both tactical – see the atomic artillery of GRABLE – and strategic nuclear weapons – see the design of fission primaries for the thermonuclear devices of CASTLE. As the first test series held after Eisenhower's inauguration, UPSHOT-KNOTHOLE occupied an important and interesting place in the narrative of U.S. nuclear testing. Eisenhower's reluctance to test nuclear weapons was made immediately clear to the NSC, while the incoming chairman of the AEC, Lewis Strauss, confidentially expressed the limits that he as chairman would impose upon testing at Nevada.[64] While the Eisenhower Administration was taking a very modest and undisclosed step backward from the escalation of testing evident after 1950 (at least, from testing in the continental United States), another message was sent to the American public with the "open" ANNIE shot, which appeared to rein in speculation and fear about the atomic bomb. That speculation and fear would however be reignited with the first shot of Operation CASTLE.

[63] See Chapter Six.

[64] Eisenhower's lukewarm enthusiasm for nuclear testing, expressed through UPSHOT-KNOTHOLE, preceded his famous "Atoms for Peace" speech before the General Assembly of the United Nations in December of 1953. For an excellent examination of this speech, see Ira Chernus, *Eisenhower's Atoms for Peace* (College Station, TX: Texas A&M University, 2002).

CASTLE

Operation CASTLE was a test series composed of six high-yield shots held at Eniwetok and Bikini atolls in the Marshall Islands in the spring of 1954. The first shot of the series, CASTLE BRAVO, dominates the discourse surrounding the test ban and the radiological dangers of atmospheric nuclear testing. It is difficult to write about the CASTLE series without discussing the vast fallout associated with BRAVO, because "BRAVO was without question the worst single incident of fallout exposure in all the U.S. atmospheric testing program."[65]

Although the device tested at IVY MIKE had demonstrated (and provided important information regarding) a thermonuclear reaction, the device itself was fuelled by liquid deuterium that required refrigeration, and as a result the device was large, unwieldy, and could not be delivered to a target using a bomber or missile.[66] CASTLE BRAVO tested a thermonuclear device fuelled by lithium deuteride, a dry fusion fuel that was more easily weaponised than that used in the IVY MIKE device. The deliverability of the hydrogen bomb became more important in the months following UPSHOT-KNOTHOLE when the Soviet Union tested a 400-kiloton device that derived much of its yield from thermonuclear fusion and was fuelled by dry hydrogen isotopes and so was deliverable.[67] In terms of strategy and doctrine, it was only after the CASTLE series that the United States possessed a deliverable hydrogen

[65] Edward J. Martin and Richard H. Rowland, "CASTLE Series, 1954," in *United States Atmospheric Nuclear Weapons Tests Nuclear Test Personnel Review* (Washington, D.C.: Defense Nuclear Agency, 1982), 235.

[66] IVY MIKE was "larger than a two-storey house and weighed some 65 tons." Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960*: 16.

[67] The Soviet test of August 1953 was more akin to a boosted-fission device than a true thermonuclear, as it was a single-stage device and not infinitely scalable. It was a closer relative of IVY KING than IVY MIKE. Yet the August 1953 test used lithium deuteride, which the U.S. would not use until CASTLE BRAVO. Holloway, *Stalin and the Bomb: The Soviet Union and Atomic Energy 1939-1956*: 305-9.

bomb, and as such CASTLE should be seen as "the culmination of the development of the super, or hydrogen, bomb that began in 1950."[68]

The six shots of CASTLE were weapons design tests that experimented with different fusion fuels and assemblies. These shots also included secondary effects experiments that focused upon "urgently needed military data" relating to blast overpressure and optimum airburst height for high-yield weapons.[69] The measurement of these effects was made difficult by the shortage of land at the Pacific atolls, "offering little dry space to place shot towers, instrumentation shelters, test structures or places to live."[70] The shortage of dry land was made particularly acute by the high yield of each of the CASTLE shots and the larger blast and fallout footprint of these tests. It was because of the small total land area of Eniwetok that the CASTLE shots were distributed between Eniwetok and Bikini (the first tests at Bikini since CROSSROADS in 1946), and the problem was also partly solved through the use of barge-mounted test devices and floating data-collection stations.[71]

Eisenhower had been again invited to witness a test of the CASTLE series. Lewis Strauss wrote to the president and suggested either the UNION or ROMEO shots, asking "will you have any interest in witnessing either of the shots?" Unlike the invitation to UPSHOT ANNIE, however, Eisenhower's response is available: "Thanks. Don't believe I can do it."[72]

[68] Martin and Rowland, "CASTLE Series, 1954," 26.
[69] Specifically, from devices that yielded greater than 540 kilotons. This information "could not be obtained from the smaller yield tests at…Nevada." Col. K.D. Coleman, et al., "Operation CASTLE: Summary Report of the Commander," (Albuquerque, New Mexico: Armed Forces Special Weapons Project, 1959), 22; Martin and Rowland, "CASTLE Series, 1954," 35.
[70] Martin and Rowland, "CASTLE Series, 1954," 51.
[71] Ibid., 51-52.
[72] Lewis L. Strauss to the President, 26 January 1954; Administration Series, Box 4; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann

At 0645 on 1 March 1954, CASTLE BRAVO exploded above Bikini Atoll with a yield of 15 megatons of TNT equivalent, or over one thousand times the yield of Little Boy.[73] Test personnel must have almost immediately realised that something was wrong with BRAVO. The device was expected to yield about five megatons, but instead ran away to triple that estimate.[74] The BRAVO device was fuelled by lithium that was enriched to roughly forty per cent lithium-6 and the remaining sixty per cent lithium-7; the temperatures and pressures of the fission primary released tritium (an isotope of hydrogen) from lithium-6.[75] Physicists had, however, underestimated the reaction of lithium-7, which was assumed to be largely inert – instead, lithium-7 underwent a reaction whereby one neutron entering the nucleus knocked two neutrons out, meaning that lithium-7 acted like enriched lithium-6 and created even more tritium for the thermonuclear reaction.[76]

A fireball almost three miles (4.8 kilometres) in diameter had formed in seconds, and gouged a crater one mile (1.6 kilometres) across and 200 feet (60 metres) in depth from the coral atoll.[77] This vaporised coral was lifted with the fireball into a cloud that after one minute was 45,000 feet (13.7 kilometres) in height.[78] The glow of the detonation was visible for a minute on Rongerik Atoll, 135 miles (250

Whitman File); Dwight D. Eisenhower Library. A wider invitation was also sent to Robert Cutler, Special Assistant to the President for National Security Affairs, which was similarly rebuffed. Lewis L. Strauss to Robert Cutler, 10 February 1954; Special Assistant Series, Subject Subseries, Box 1; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.

[73] "United States Nuclear Tests: July 1945 through September 1992," 4-5.

[74] Rhodes, *Dark Sun: The Making of the Hydrogen Bomb*: 541.

[75] Ibid. and Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960*: 17.

[76] Ibid.

[77] Martin and Rowland, "CASTLE Series, 1954," 205.

[78] Ibid.

kilometres) east of Bikini.[79] The shock wave shook windows on Rongerik eleven minutes after the detonation.

The task force fleet assembled around Bikini began to receive fallout just over an hour after the detonation. The fallout "resembled pinhead-sized white and gritty snow," and forced the cancellation of helicopter surveys of the atoll.[80] This gritty snow was irradiated coral falling from the bomb cloud. Marshall Rosenbluth described the fallout: "I was on a ship that was thirty miles [forty-eight kilometres] away, and we had this horrible white stuff raining out on us…it was pretty frightening."[81] Radiation levels on the task force ships rose quickly and after five minutes these ships were ordered south at best speed.[82] The image of the test fleet rapidly retreating from the expanding mushroom cloud of BRAVO is a powerful one.

Irradiated along with the task force fleet was a Japanese fishing boat, the *Daigo Fukuryu Maru* (*Lucky Dragon 5*), trawling eighty-five miles (136 kilometres) east of Bikini. A crewmember who witnessed the BRAVO detonation reported to his colleagues that "the sun rises in the west."[83] Calcined coral rained out over the trawler and coated it and its crew with a "sandy white ash."[84] Despite aerial patrols to secure the test area and track the bomb cloud and fallout, the task force was unaware of the

[79] Ibid.

[80] Ibid., 210.

[81] Recall Rosenbluth was the physicist who described the GREENHOUSE GEORGE shot as like using a blast furnace to light a match. Rhodes, *Dark Sun: The Making of the Hydrogen Bomb*: 541.

[82] Martin and Rowland, "CASTLE Series, 1954," 210. Elements of the fleet received a second dusting of fallout from the early afternoon through to the evening "composed of much smaller particles that had taken considerably longer to fall from the great heights of the bomb cloud than the large particles of the morning fallout." Ibid., 217.

[83] Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960*: 4.

[84] Ibid.; Rhodes, *Dark Sun: The Making of the Hydrogen Bomb*: 542; Martin, "CASTLE Series, 1954." 212.

trawler until it returned to port in Japan.[85] The crew was hospitalised for weeks with acute radiation sickness, and the radioman – Aikichi Kuboyama – died on 24 September.[86]

At Rongerik Atoll, fallout gathered to a depth of half an inch (1.2 centimetres) and left "a visible layer on tables in the mess hall and barracks."[87] Personnel were evacuated from Rongerik the day after the BRAVO shot, along with indigenous Marshallese from the surrounding atolls. Many of these evacuees suffered radiation burns as a result of their exposure, and some of the Marshallese developed severe blood disorders.[88] At about the same time that these evacuations were being undertaken, a fuel tanker *en route* from Eniwetok to Pearl Harbour received fallout at

[85] There was some confusion regarding the aerial patrol that should have detected the *Fukuryu Maru*. A P2V aircraft swept the area after the shot but was forced to cancel its mission when it became "heavily contaminated" by fallout. Accounts differ on how far east this aircraft had travelled before it broke off its search: one account suggests that it turned back to Kwajalein just before the *Fukuryu Maru* would have been detected, while another suggests that it should have easily detected the trawler. Martin and Rowland, "CASTLE Series, 1954," 213. The former scenario seems more likely to this author.

[86] The exposure of the *Fukuryu Maru* to fallout became a tense diplomatic issue long before Kuboyama's death. The U.S. ambassador to Japan, John M. Allison, wrote a long cable articulating "unpleasant…even ominous" conclusions regarding the incident. Eisenhower was "concerned about the Japanese situation as reported by Allison" and requested more information from the State Department. The State Department recommended at the end of May (four months before Kuboyama's death) that $150,000 be paid as compensation; the U.S. eventually paid two million dollars in compensation to Japan. Telegram to the Secretary of State from Tokyo, 20 May 1954; Dulles-Herter Series, Box 3; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library; Memorandum for the Secretary of State from the President, 26 May 1954; Dulles-Herter Series, Box 3; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library; and Memorandum for the President from Robert Murphy, Acting Secretary of State, 29 May 1954; Dulles-Herter Series, Box 3; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

[87] Martin, "CASTLE Series, 1954," 217.

[88] Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960*: 29.

a distance of 586 miles (1,084 kilometres) from Bikini.[89] Such was the extent of the fallout from CASTLE BRAVO that "not only were U.S. military personnel [exposed], but also foreign nationals and Marshall Islanders."[90]

Lewis Strauss observed the BRAVO and ROMEO shots, and returned to Washington at the end of March; he then released a statement addressing the fallout concerns of BRAVO. He rejected the notion that BRAVO was "out of control" or "devastating," stating that "the yield was about double that of the calculated estimate – a margin of error not incompatible with a totally new weapon," and instead attributed the fallout to an unexpected shift in wind direction.[91]

The radiological contamination caused by BRAVO affected the rest of the CASTLE series. Because of the contamination of Bikini Atoll, test personnel received cumulative radiation doses that exceeded the maximum limit, which consequently led to a "gradual loss of personnel" (this despite the issuance of waivers permitting

[89] This ship was the *Patapsco*, and was associated with the CASTLE series. It had hurriedly left the test area two days before BRAVO because it lacked adequate protection against radiation. Martin, "CASTLE Series, 1954," 230.

[90] Ibid., 235. Across Rongerik, Rongelap, Ailinginae and Uterik Atolls, 28 U.S. personnel received a gamma dosage of 86 roentgens, 64 Marshallese received 183 roentgens, 18 Marshallese received 81 roentgens and 157 Marshallese received 13 roentgens, respectively. This dosage was accumulated between 4 and 78 hours after detonation. The operational limit for test personnel set at the beginning of CASTLE was 3.9 roentgens over a 13-week period. Coleman, "Operation CASTLE: Summary Report of the Commander," 71; Martin and Rowland, "CASTLE Series, 1954," 3. Cronkite et al. note that the maximum permissible exposure was set at 20 roentgens for the Marshallese, five times higher than the limit set for U.S. personnel. Cronkite, "Historical Events Associated with Fallout from Bravo Shot - Operation Castle and 25 Y of Medical Findings," 177.

[91] This was the same statement, mentioned in the introduction to this thesis, in which he described nuclear weapons testing as "this awesome field." Statement by Lewis L. Straus, Chairman, Atomic Energy Commission, 31 March 1954; Press Conferences Series, Box 2; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

exposures to almost double the operational limit).[92] The blast from BRAVO had also destroyed support facilities at Bikini Atoll. Further compromised by poor weather, the remaining shots of CASTLE were rescheduled and reordered. Shot ECHO was cancelled because of personnel exposure, shot NECTAR was moved from Bikini to Eniwetok, and shot ROMEO was moved to the crater formed by BRAVO. Not only were test devices and barges relocated but observation and measurement instrumentation as well, and all labour was carried out in a radioactive environment.[93]

Shots ROMEO, KOON, UNION and YANKEE were fired at Bikini Atoll, and were all megaton-range thermonuclear tests with the exception of KOON which "almost fizzled" at 110 kilotons.[94] NECTAR was fired at Eniwetok Atoll in the crater created by IVY MIKE and yielded 1.69 megatons. Although many of these shots were very high-yield – YANKEE, for example, yielded 13.5 megatons – none created the same widespread radiological contamination as BRAVO. Over a month after the NECTAR shot, Lewis Strauss together with Charles E. Wilson, the secretary of defense, issued a brief statement declaring that the "1954 series of thermonuclear tests…has been completed" and that these tests "were successful in the development of thermonuclear weapons."[95]

Strauss's statement belied the public unrest that emerged as details of the fallout from BRAVO became known. It was criticism of this fallout, both international and domestic, that was the catalyst for, and driving force behind, the

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[92] Martin and Rowland, "CASTLE Series, 1954," 4, 246.
[93] Ibid., 248-49.
[94] Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960*: 25; Martin, "CASTLE Series, 1954," 267; "United States Nuclear Tests: July 1945 through September 1992," 4-5.
[95] Statement by L. L. Strauss, Chairman, AEC, and Charles E. Wilson, Secretary, DOD, 18 June 1954; OF108 Atomic Energy-Atomic Power, 1957, Box 450; Official File; White House Central Files; Dwight D. Eisenhower Library.

embryonic test ban debate.[96] Strauss was forced to reply to this growing criticism in a lengthy press conference in December of 1954, after which a report by the AEC on high-yield nuclear explosions was made public.[97] This statement and the attached report make for interesting reading. After a cogent summary of the interaction of a nuclear fireball with the Earth's surface and the distribution of fallout, Strauss dispassionately commented that BRAVO released sufficiently radioactive fallout "in a downwind belt about 140 miles (225 kilometres) in length and of varying width up to 20 miles (32 kilometres) to have seriously threatened the lives of nearly all persons in the area *who took no protective measures*."[98] But Strauss also defended the high-yield tests of CASTLE:

[96] Robert Divine made this argument in 1978 but added that while Eisenhower was president a pattern emerged in which "sudden interest in nuclear tests" led to "intense debate and public discussion, and then the equally abrupt dropping of this issue." Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960*: 27. Glenn Seaborg, chairman of the AEC under Kennedy and Johnson, explicitly connected "widespread public concern" with the BRAVO fallout to disarmament proposals, including the test ban. Glenn T. Seaborg, *Kennedy, Khrushchev, and the Test Ban* (Berkeley: University of California Press, 1981), 3-4. Benjamin Greene has more recently argued that the Eisenhower Administration first seriously considered a test ban proposal in 1954, in the aftermath of BRAVO. Greene, *Eisenhower, Science Advice, and the Nuclear Test Ban Debate, 1945-1963*: 68-86.

[97] Elements of the Administration resisted the publication of this report, arguing that it "could have serious and far-reaching adverse effects upon our foreign programs, particularly in Western Europe." Memorandum for Mr. Max Raab, Secretary to the Cabinet from Elmer B. Staats, Executive Office, Operations Coordinating Board, 9 December 1954; Cabinet Secretariat: Records, 1953-1960, Box 1; White House Office, Dwight D. Eisenhower Library. Divine argues that the report was delayed until February 1955 to allow the State Department to negotiate with NATO countries the rearmament of West Germany. Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960*: 36.

[98] Statement by Lewis L. Strauss, Chairman, United States Atomic Energy Commission, February 1955; Cabinet Secretariat: Records, 1953-1960, Box 1; White House Office, Dwight D. Eisenhower Library. Emphasis from the original. Strauss went on to say that "about 7,000 square miles (11,265 square kilometres) of territory downwind from the point of burst [of BRAVO] was so contaminated that survival

> It should be noted that if we had not conducted the full-scale thermonuclear tests mentioned above, we would have been in ignorance of the extent of the effects of radioactive fallout and, therefore, we would have been much more vulnerable to the dangers from fallout in the event an enemy should resort to radiological warfare against us.[99]

Moreover, the report concluded, "a certain element of risk is involved in the testing of nuclear weapons" – which seems indisputable, although the scale of that risk certainly was not akin to "manufacturing conventional explosives or in transporting inflammable substances such as oil or gasoline on our streets and highways," as was suggested.[100]

One dimension of the importance of the CASTLE series that should not be taken for granted was that BRAVO set the upper limit for the yield of U.S. nuclear tests, and also proved the sensibility of overseas testing. Although largely accidental, the high yield and widespread fallout associated with BRAVO had the effect of capping U.S. tests in the Pacific at around 15 megatons, just as UPSHOT CLIMAX had the effect of stabilising the upper limit of tests at Nevada. Both Eisenhower and Sterling Cole, chairman of the Joint Committee of Atomic Energy, affirmed in the aftermath of BRAVO that "we [the U.S.] have no intention of seeking ways to make

might have depended upon prompt evacuation of the area or upon taking shelter…"

[99] A Report by the United States Atomic Energy Commission on the Effects of High-Yield Nuclear Explosions, February 1955; Cabinet Secretariat: Records, 1953-1960, Box 1; White House Office, Dwight D. Eisenhower Library. This comment should be compared with one made by Strauss in his statement of March, in which he said that "one important result of these hydrogen bomb developments has been the enhancement of our military capability." Here we see a hint of the blurred line between weapons development and weapons effects tests and the complex interrelationship between these. Statement by Lewis L. Straus, Chairman, Atomic Energy Commission, 31 March 1954; Press Conferences Series, Box 2; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

[100] A Report by the United States Atomic Energy Commission on the Effects of High-Yield Nuclear Explosions, February 1955; Cabinet Secretariat: Records, 1953-1960, Box 1; White House Office, Dwight D. Eisenhower Library.

larger ones [higher-yield thermonuclear weapons]."[101] CASTLE also seemed to justify, at least to Lewis Strauss, the conduct of high-yield atmospheric tests in the Pacific Trust Territory. In March he reminded his audience that it was "for this reason [the distribution of fallout] the Atomic Energy Commission has conducted tests of its largest weapons away from the mainland so that fall-out [sic] would occur in the ocean"; while in December he more explicitly communicated the separate functions of the test sites when he said that "only relatively small nuclear test explosions are conducted at the Nevada Test Site, in contrast to the high-yield thermonuclear devices at the Pacific Proving Grounds."[102]

Operation CASTLE was probably the most important test series conducted during the Eisenhower Administration, because it was unique in that it was simultaneously crucial to two dimensions not often reconciled: both for weapons design and for the test ban. The connection between these two dimensions was a close one, but the second was not possible without the first: it was the sheer scale of the detonation that made BRAVO important for weapons design, but the dangers of nuclear testing were more widely recognised as a consequence of that scale. CASTLE BRAVO demonstrated important developments in thermonuclear weapons, but at the same time the extensive fallout associated with the shot was the catalyst for

[101] Letter to W. Sterling Cole from President Eisenhower, 8 April 1954; Name Series, Box 6; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library; Letter to the President from Sterling Cole, 5 April 1954; Name Series, Box 6; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

[102] Statement by Lewis L. Straus, Chairman, Atomic Energy Commission, 31 March 1954; Press Conferences Series, Box 2; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library; Statement by Lewis L. Strauss, Chairman, United States Atomic Energy Commission, February 1955; Cabinet Secretariat: Records, 1953-1960, Box 1; White House Office, Dwight D. Eisenhower Library.

arguments regarding a ban on weapons testing. Because of that fallout, and because it remained the highest yield shot ever fired by the United States, BRAVO henceforth cast a shadow over U.S. nuclear weapons tests.

TEAPOT

Operation TEAPOT consisted of fourteen nuclear tests and one non-nuclear test, and was the fifth series held at the Nevada Test Site and tenth held since the end of the Second World War.[103] It was held between February and May of 1955, during which time the First Taiwan Strait Crisis (September 1954 – May 1955), the sovereignty of West Germany and the formation of the Warsaw Pact (May 1955) further defined the Cold War.

The request for approval of TEAPOT was sent to Eisenhower at the end of August 1954. This was before the death of Aikichi Kuboyama as a result of CASTLE BRAVO. In his request, Strauss identified "a number of ideas that are highly important to the development" of tactical, air defense and light-weight thermonuclear weapons and that "verification of some of these ideas within the limits of laboratory techniques will be completed in late 1954," necessitating a series of tests "to maintain progress in this field."[104] Robert Cutler replied on behalf of Eisenhower one week later and approved Strauss' request.[105]

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[103] The non-nuclear test was shot HADR (High Altitude Dress Rehearsal), a high-explosive device detonated to calibrate measurement equipment and practice for the nuclear shot HA (High Altitude).

[104] Lewis Strauss to President Eisenhower, 30 August 1954; Executive Secretary's Subject File Series, Box 4; National Security Council Staff: Papers, 1948-1961; White House Office; Dwight D. Eisenhower Library.

[105] Memorandum for the Chairman, Atomic Energy Commission from Robert Cutler, 7 September 1954; NSC Series, Subject Subseries, Box 1; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.

Of the fourteen nuclear tests of TEAPOT, four were primarily weapons effects tests and the remaining ten were weapons design tests – although these definitions relate to their primary purpose, and multiple experiments relating to both paradigms were conducted at each shot.[106] The goals of these tests were to develop small-diameter implosion systems for use in air defense and tactical weapons; develop small thermonuclear weapons for use by ground support aircraft and guided missiles; and further develop understanding of the military effects of nuclear explosions, especially for civil defense purposes.[107]

TEAPOT also involved training programs for the armed forces. Shots WASP and WASP PRIME – 1 and 3 kilotons of TNT equivalent, respectively – were used by the Strategic Air Command to test airdrop delivery techniques.[108] Similarly, approximately 8,000 personnel took part in the DESERT ROCK VI exercises at shots WASP, MOTH, TESLA, TURK, BEE, ESS, APPLE 1, MET and APPLE 2.[109] The tactical exercise conducted at APPLE 2, which yielded 29 kilotons, was the largest of the TEAPOT series, and involved a tank battalion reinforced with mechanised and helicopter-borne infantry assaulting a position close to ground zero.[110]

Notable about Operation TEAPOT was the novelty of at least two of the shots. Shot HA was the first high-altitude test held by the U.S., and was detonated at an

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[106] "United States Nuclear Tests: July 1945 through September 1992," 4-7.

[107] Lewis Strauss to President Eisenhower, 14 January 1955; Administration Series, Box 4; Eisenhower, Dwight D.: Papers and President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library. Two of the five stated purposes remain redacted.

[108] Jean Ponton, et al., "Operation TEAPOT, 1955," in *United States Atmospheric Nuclear Weapons Tests Nuclear Test Personnel Review* (Washington, D.C.: Defense Nuclear Agency, 1981), 34; "United States Nuclear Tests: July 1945 through September 1992," 4-7.

[109] Ponton, "Operation TEAPOT, 1955," 35, 60.

[110] Ibid., 67-68.

altitude of 36,620 feet (11.16 kilometres), yielding 3 kilotons. Conversely, shot ESS was the deepest shot yet fired underground, and was detonated seventy feet (20 metres) beneath the surface, yielding 1 kiloton.[111] Both underground and high-altitude tests would receive greater attention in the PLUMBBOB, HARDTACK and ARGUS series. Similarly, TEAPOT included the highest percentage of weapons effects tests of any series yet held by the United States.[112]

From the perspective of the historical narrative of U.S. nuclear testing, however, TEAPOT was most interesting for its modesty. It represented an unintentional pause after CASTLE. TEAPOT was held to improve tactical nuclear weapons systems, which indeed it did, but nowhere were the dramatic field tests of atomic artillery like UPSHOT GRABLE. Similarly, the sixth DESERT ROCK exercise was of lesser scale than those that had preceded it. It was perhaps the habit of alternating test series between Nevada and the Pacific, between low and high yield, that led to the characteristic of domestic debate about nuclear testing that Divine noted – that pattern where controversy and opposition would suddenly spike and then abruptly fade away.

WIGWAM

Operation WIGWAM was a one-shot test series held in the Pacific Ocean at the same time that TEAPOT was concluding in Nevada.[113] WIGWAM involved a

[111] Ibid., 9; "United States Nuclear Tests: July 1945 through September 1992," 4-7. For comparison, the only previous subsurface shot, JANGLE UNCLE, was detonated at a depth of seventeen feet (5 metres). Ponton, "Operation BUSTER-JANGLE, 1951," 26.

[112] Both BUSTER-JANGLE and TEAPOT involved four tests explicitly conducted for weapons effects purposes; TEAPOT, however, involved fewer shots overall, making 28.5% of the shots of Operation TEAPOT weapons effects tests.

[113] WIGWAM was detonated on 14 May 1955 while the last shot of TEAPOT

single deep-underwater nuclear test that included many of the experiments that were associated with the cancelled CHARLIE shot of Operation CROSSROADS in 1946.

WIGWAM was fired at a location approximately 500 miles (804 kilometres) south-west of San Diego, California.[114] WIGWAM was the first of only two shots fired in this area in the history of U.S. nuclear testing, and the first test conducted outside the Pacific Proving Ground or Nevada Test Site since TRINITY in 1945.[115] It was a location carefully selected through oceanographic surveys to provide the essential conditions for the test – that is, of sufficient depth to contain the detonation – while also to minimise radiological contamination – with well-known currents and far from shipping lanes and fishing areas.[116]

The primary purpose of WIGWAM was "to obtain information from which can be determined the maximum range at which hull-splitting damage to a submerged typical submarine at a single depth can be assured."[117] Related to this primary purpose was the need to determine "the safe range for a surface ship in the vicinity of this [underwater nuclear] detonation," and "determine the fallout and contamination problems resulting from the explosion."[118]

ZUCCHINI was detonated on 15 May.

[114] Following the convention of the Department of Energy, and because the WIGWAM series involved only one shot, WIGWAM shall be used to refer interchangeably to both the series and shot name. "United States Nuclear Tests: July 1945 through September 1992," 6-7.

[115] The second shot was SWORDFISH of Operation DOMINIC in 1962 that also tested an antisubmarine weapon. See Chapter Five.

[116] S.E. Weary, et al., "Operation WIGWAM," in *United States Atmospheric Nuclear Weapons Tests Nuclear Test Personnel Review* (Washington, D.C.: Defense Nuclear Agency, 1981), 1-11.

[117] Letter from Lewis Strauss and Robert B. Anderson to President Eisenhower, 8 December 1954; Administration Series, Box 4; Eisenhower, Dwight D.: Papers and President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

[118] Weary, "Operation WIGWAM," 3-1.

The WIGWAM device was detonated at a depth of 2,000 feet (609 metres) and yielded 30 kilotons of TNT equivalent.[119] None of the task force ships was closer than 30,000 feet (9.1 kilometres) from the test device, and almost all were upwind of the detonation point.[120] All of the initial energy of the device was contained within the water – unlike CROSSROADS BAKER, a shallow underwater test, in which much of the energy escaped into the atmosphere – and it was this characteristic of the test that most interested the U.S. Navy.[121]

The depth of the WIGWAM test also made WIGWAM the cleanest U.S. nuclear test series. Of the oceanic test series conducted by the United States between 1946-1962, the average percentage of test personnel who received zero radiation exposure was 32% while for continental test series that percentage was 52%; for WIGWAM, 94% per cent of personnel received a radiation exposure of zero. The remaining 6% of personnel at WIGWAM received a dosage no greater than .425 roentgens, while 13% of personnel in oceanic test series received between 1 and 3 roentgens and 5% of personnel received more than 3 roentgens.[122]

WIGWAM was essential in the development of anti-submarine tactics and atomic depth charges, but more than that it opened up an entirely new medium and manner in which to test nuclear weapons.[123] Deep underwater tests offered a relatively

[119] Letter from Lewis Strauss and Robert B. Anderson to President Eisenhower, 8 December 1954; Administration Series, Box 4; Eisenhower, Dwight D.: Papers and President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library and "United States Nuclear Tests: July 1945 through September 1992," 6-7.
[120] Weary, "Operation WIGWAM," 1-13.
[121] Ibid., 1-3.
[122] Ibid., 4-4 and 4-5. The averages for oceanic test series were, presumably, spiked by CASTLE BRAVO.
[123] Letter from Lewis Strauss and Robert B. Anderson to President Eisenhower, 8 December 1954; Administration Series, Box 4; Eisenhower, Dwight D.: Papers and

safe and reliable way to test nuclear weapons that contrasted dramatically with CASTLE BRAVO. Alongside high-altitude and underground tests, underwater tests added more complexity to the debate regarding a nuclear test ban, and would complicate the monitoring of such a ban. These issues will be further discussed in Chapters Four and Six.

REDWING

Operation REDWING was a seventeen-shot test series held at the Pacific test site during the summer of 1956. It was the first series held at Bikini and Eniwetok Atolls since the fallout of the CASTLE series, and presumably for this reason REDWING went against the trend of increasing yield for each subsequent Pacific test series. Despite its relative restraint compared to CASTLE, REDWING was nonetheless a high-yield series, and was held "primarily to test high-yield thermonuclear devices that could not be tested in Nevada."[124]

Lewis Strauss identified four objectives for REDWING in his letter to Eisenhower seeking presidential approval for the series. The first objective was to "proof-test certain weapons in stockpile or to be stockpiled in the near future," likely next generation thermonuclear weapons based on the results of IVY and CASTLE; the second objective was "to continue developmental research on promising weapons"; the third objective was "to continue long range weapons research of new techniques, ideas and designs," although how this differed from the second objective is unclear; and finally, "to conduct a weapons effects program required by the

President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

[124] S. Bruce-Henderson, et al., "Operation REDWING: 1956," in *United States Atmospheric Weapons Tests Nuclear Test Personnel Review* (Washington, D.C.: Defense Nuclear Agency, 1982), 2.

Department of Defense."[125] This same request from Strauss made the first connection between testing and the development of surface-to-air missiles – described as "the air defense problem" – along with clean fusion weapons, both of which would become increasingly important in the second Eisenhower Administration.[126]

Debate preceded REDWING regarding public attendance of the tests. Herbert Hoover, former president and advisor to the Truman and Eisenhower Administrations, counselled against press access to REDWING – fearing the kind of "sensational" incident that had followed CASTLE BRAVO.[127] Hoover was supported by John Foster Dulles, the secretary of state, and the Operations Coordinating Board (OCB). The AEC, however, felt that "barring its [the American Press] representatives from the test may cause not only embarrassment but hostile and distorted reporting based upon speculation and leaks, particularly if any embarrassing incident occurs."[128] Eisenhower eventually worked out a compromise involving a limited number of press and foreign observers.[129]

[125] Letter from Lewis Strauss to President Eisenhower, 5 March 1956; Subject Series, Box 9; White House Central Files (Confidential Files), 1953-1961; Eisenhower, Dwight D.: Records as President; Dwight D. Eisenhower Library.
[126] Ibid. The anti-ballistic missile and clean fusion weapons will be further explored in Chapter Four.
[127] "It is Mr. Hoover's view that publicity regarding the test, some of which may be sensational, will adversely affect the US throughout the world." Memorandum for the President from William H. Jackson, 7 March 1956; Administration Series, Box 22; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.
[128] Ibid.
[129] Members of the U.S. press were kept to a minimum, and foreign observers were limited to twenty and represented allies in NATO, South America, Asia and the South Pacific. Memorandum of Conference with the President March 21, 1956, 22 March 1956; DDE Diary Series, Box 13; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

At least fifteen "news representatives" attended the CHEROKEE shot, the second of the REDWING series and the first conducted at Bikini Atoll.[130] CHEROKEE involved an airdrop from an operational B-52 bomber of a thermonuclear bomb, and "although of some scientific interest, was probably more a demonstration to the world of the deliverability of these weapons than an experiment."[131] The yield of CHEROKEE was 3.8 megatons of TNT equivalent, and far exceeded UPSHOT ANNIE, the test conducted at Nevada in 1953 that had also been observed by the press.[132] CHEROKEE detonated at an altitude of 5,000 feet (1.5 kilometres) but was considerably off target. Sources do not agree on how inaccurate CHEROKEE was – Strauss told Eisenhower it was 2.6 miles (4.2 kilometres) off target, while more recent scholarship argues it was 3.8 miles (6.1 kilometres) off target – but using either figure the CHEROKEE airdrop was far less accurate than the previous airdrop over Bikini, CROSSROADS ABLE in 1946, which had also missed its target but only by a distance of 2,130 feet (650 metres).[133] In a letter to Colonel A.J. Goodpaster, advisor to President Eisenhower, Strauss described this lack of accuracy as an "error in point-of-aim," and excluded the incident from the

[130] There were fifteen members of the press, one representative of the United States Information Agency and "about" twenty civil defense observers in attendance. Letter from Lewis Strauss to James C. Hagerty, Secretary to the President (Press), 2 April 1956; OF108 Atomic Energy-Atomic Power, 1957, Box 450; Official File, 1953-1961; White House Central Files; Dwight D. Eisenhower Library. These were the first press observers to attend a Pacific test since CROSSROADS in 1946. Bruce-Henderson, "Operation REDWING: 1956," 22.
[131] As a high-yield airburst shot, CHEROKEE should have provided information regarding air blast effects. Ibid., 2, 177.
[132] "United States Nuclear Tests: July 1945 through September 1992," 6-7.
[133] Letter from Lewis Strauss to President Eisenhower, 22 May 1956; Administration Series, Box 4; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library and Bruce-Henderson, "Operation REDWING: 1956," 181. Divine quotes the larger figure. Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960*: 77.

information he recommended Eisenhower mention in the president's press conference.[134]

The inclusion of the press at CHEROKEE was a success but the scientific results were not. Writing to James Hagerty, the press secretary, after CHEROKEE, Strauss described the invitation to the press as a "ten-strike," and that all the stories about CHEROKEE were "devoid of horror overtones" and "obvious attempts to be as factual as possible."[135] Moreover, the United States had demonstrated to the world its ability to deliver multi-megaton thermonuclear bombs from its existing strategic bomber platforms, and also demonstrated the progress made in the design of thermonuclear weapons from IVY and CASTLE. But the value of scientific data from CHEROKEE was lessened by the inaccurate delivery of the airdrop, and Strauss informed Eisenhower that "this error will result in a substantial loss of measurement data."[136]

The remaining shots of REDWING were conducted without problem with the exception of ZUNI and TEWA. Fired a week after CHEROKEE, shot ZUNI was conducted on the same island as CASTLE KOON. The high yield (3.5 megatons) and surface placement of ZUNI destroyed the western end of Eneman Island and carried the constituent material aloft in the bomb cloud. But CASTLE KOON, which had "almost fizzled" two years prior, deposited fissile material not consumed in the

[134] Strauss did, however, recommend that the president announce that the yield of CHEROKEE was "substantially below that of the largest detonations that have heretofore taken place at the [Pacific] proving grounds." Memorandum to Colonel Goodpaster from Lewis Strauss, 22 May 1956; Subject Series, Alphabetical Subseries, Box 3; White House Office: Office of the Staff Secretary, 1952-1961; Dwight D. Eisenhower Library.
[135] Letter from Lewis Strauss to James Hagerty, 24 May 1956; OF108 Atomic Energy-Atomic Power, 1957, Box 450; Official File, 1953-1961; White House Central Files; Dwight D. Eisenhower Library.
[136] Bruce-Henderson, "Operation REDWING: 1956," 177-82.

reaction across Eneman Island; this residue of plutonium and uranium was vapourised and dispersed by the ZUNI shot. ZUNI and the remains of KOON thus heavily irradiated most of Bikini Atoll and "very light fallout" was reported on Eniwetok.[137]

TEWA was the highest-yield shot fired during REDWING and caused the most serious fallout of the series. It was fired from a barge inside Bikini Atoll and yielded 5 megatons of TNT equivalent.[138] TEWA heavily contaminated the northern islands of the atoll, delaying recovery teams, but an unexpected change in winds shifted the stem and upper portion of the bomb cloud toward Eniwetok Atoll.[139] Fallout reached Eniwetok nine hours after the shot and continued to fall for seventeen hours, and was concentrated by rain showers.[140] Personnel at both Bikini and Eniwetok Atolls received maximum dosages of 2.5 roentgens (far less than U.S. personnel on Rongerik Atoll after CASTLE BRAVO); nonetheless, the maximum permissible exposure for the REDWING series was raised from 3.9 roentgens to 7 roentgens after TEWA.[141]

The REDWING series of tests demonstrated a natural progression in thermonuclear weapons design. Where IVY MIKE demonstrated a fusion reaction and CASTLE BRAVO demonstrated a fusion reaction using dry lithium deuteride, REDWING CHEROKEE demonstrated a clearly weaponised device and its delivery. Yet, despite the increase in number of shots per series, a trend that had moved upward from the beginning of U.S. testing with only a few exceptions, REDWING challenged the related tendency of increasing yield. To be fair, it would have been very difficult indeed to exceed the runaway yield of the CASTLE series – but not impossible and, it

[137] Ibid., 45, 182-88.
[138] "United States Nuclear Tests: July 1945 through September 1992," 8-9.
[139] Bruce-Henderson, "Operation REDWING: 1956," 206.
[140] Ibid., 210.
[141] Ibid., 212.

must be stressed, REDWING was the first opportunity to challenge that trend. REDWING arrested the tendency toward higher and higher yields so that while it would itself be eclipsed by HARDTACK I, no series exceeded the yield of CASTLE. Nevertheless, while the total yield of REDWING was less than a third of the total yield of CASTLE, six of its seventeen shots – or thirty-five per cent of the series – were of megaton-range weapons. This detail is not insignificant given the vastly greater scope of REDWING, which included almost three times as many shots as CASTLE and almost nine times as many shots as IVY.

PLUMBBOB

Operation PLUMBBOB was an extensive test series held at Nevada between May and October of 1957 and involved twenty-four nuclear shots and five safety experiments. Included in PLUMBBOB was the highest-yield atmospheric test ever held in the continental United States as well as a deep underground shot that profoundly affected concurrent negotiations for a test ban between the nuclear powers. It was this latter shot for which PLUMBBOB is most important, because "as the PLUMBBOB series went forward, the international effort was turning toward cessation of future testing."[142]

Lewis Strauss wrote to Eisenhower in December 1956 seeking approval for what was then known as Operation PILGRIM. Although "it was not possible at the present moment to specify exactly what shots are to be fired," Strauss estimated

[142] P.S. Harris, et. al., "PLUMBBOB Series, 1957," in *United States Atmospheric Weapons Tests Nuclear Test Personnel Review* (Washington, D.C.: Defense Nuclear Agency, 1981), 32. The effort toward a test ban and the effect of PLUMBBOB RAINIER upon this effort shall be further discussed in Chapter Four.

approximately twenty-five nuclear shots and five or more safety tests.[143] The schedule depended upon the results of REDWING that were still being analysed when Strauss sought Eisenhower's approval; nonetheless, the letter outlined a set of general objectives. These included: tests of "certain air defense and anti-submarine warheads"; tests of "components and mockups which provide design information for thermonuclear devices" to be tested at HARDTACK I in 1958; "development tests toward achieving more efficient use of active material and warheads of smaller size and weight"; and a "deep underground test designed to explore this manner of testing."[144] The shots of PLUMBBOB were thus largely weapons design tests, and involved either proof testing of existing designs or data capture for subsequent designs – but not exclusively so. PLUMBBOB also involved safety tests of high-explosive lenses and weapons effects tests for both the Department of Defense and the FCDA.[145] Eisenhower's approval of PLUMBBOB was conditional, "subject to his understanding that all the tests proposed will be held in Nevada."[146]

Eisenhower's conditional approval could be interpreted as reluctance. The president certainly voiced reluctance in a meeting with the secretary of state, deputy

[143] Letter from Lewis Strauss to President Eisenhower, 21 December 1956; Administration Series, Box 4; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library. Interestingly, a second version of this letter can be found outside the Ann Whitman File, and this version is considerably redacted. Comparing the two versions gives an idea of the sensitivity of the information contained within. Of the objectives laid out for the president, the most sensitive appears to be the development of components for thermonuclear devices tested in subsequent series, as well as the types of air defense and anti-submarine warheads to be tested. Letter from Lewis Strauss to President Eisenhower, 21 December 1956; Subject Series, Box 9; White House Central Files (Confidential File), 1953-1961; Eisenhower, Dwight D.: Records as President; Dwight D. Eisenhower Library.
[144] Ibid.
[145] Ibid and "United States Nuclear Tests: July 1945 through September 1992," 8-11.
[146] Ibid.

under-secretary of state and General Goodpaster less than a week after Strauss's request and two days before Eisenhower's approval. Referring to Strauss's proposal, Eisenhower "expressed some doubt as to the advisability of these tests."[147] John Foster Dulles perceived "no difficulty" from the PLUMBBOB tests, because a recent Soviet test series "had provoked little comment." [148] Eisenhower noted that "practically all of these explosions would be small," but it was not until two months later that Strauss informed him that "none of [the PLUMBBOB shots] will be designed to yield more than 80 KT"[149] – an upper limit that represented the highest yield of any test held in the continental United States and significantly higher than the 61 kilotons of UPSHOT CLIMAX that Strauss had recommended against four years earlier. One wonders at Eisenhower's sense of "small", whether that sense had been affected by the multi-megaton shots in the Pacific, and wonders, too, at the president's reaction to Strauss's letter of 21 February.

A number of the shots of PLUMBBOB are worth mention. There were at least two, possibly three, fizzles – very likely shots FRANKLIN and LASSEN in June, and possibly DIABLO in July. Strauss requested presidential authority to expend additional fissile material in August, stating that "the additions are due to the necessity to fire again modified versions of two earlier shots which did not realize the

[147] Memorandum of Conversation, Nuclear Tests, 26 December 1956; Dulles-Herter Series, Box 8; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

[148] By "little comment" Dulles presumably referred to international criticism, as he explicitly connects PLUMBBOB to the Nevada Test Site and the Soviet test series as held "inside the Soviet Union." This connection to testing inside a state's borders might explain Eisenhower's conditional approval of PLUMBBOB. Ibid.

[149] Ibid and Letter to the President from Lewis Strauss, 21 February 1957; Subject Series, Box 9; White House Central Files (Confidential File), 1953-1961; Eisenhower, Dwight D.: Records as President; Dwight D. Eisenhower Library.

required yield."[150] Although he did not mention the shots by name, Strauss likely referred to FRANKLIN, the second shot of the series, which yielded only 140 tons of TNT equivalent, and LASSEN, the third shot, which yielded half a ton.[151] A later analysis also mentions DIABLO, which purportedly "misfired" yet still yielded 17 kilotons; it is possible that this was one of the shots to which Strauss referred although the relative yield makes it unlikely.[152] At the opposite end of the spectrum was shot HOOD, which yielded 74 kilotons and was presumably that device to which Strauss referred in his letter of 21 February. HOOD was in excess of the yield of UPSHOT CLIMAX, which before PLUMBBOB had been the highest yield test held at Nevada.

The JOHN shot was the first operational test of a nuclear warhead in an air-to-air missile. JOHN detonated at 18,500 feet (5,638 metres) and yielded approximately 2 kilotons.[153] JOHN was significant for two reasons: first, because Charles E. Wilson, the secretary of defense, explicitly connected the development of this nuclear air-to-air missile to the HA shot of Operation TEAPOT in 1955; and second, because in the same statement, made in January 1957, Wilson said that the Department of Defense had already begun deployment of the missile that would not be proof tested until JOHN in July 1957.[154] These two comments from the secretary of defense suggest

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[150] Letter to President Eisenhower from Lewis Strauss, 7 August 1957; Administration Series, Box 5; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

[151] Both of these shots are classified as "weapons related" tests and are quite distinct from the non-nuclear safety experiments that yielded even less energy. "United States Nuclear Tests: July 1945 through September 1992," 8-9.

[152] Harris, "PLUMBBOB Series, 1957," 4.

[153] Six volunteers observed the JOHN shot from ground zero. Because of the low yield and high altitude of JOHN, none of these observers received radiation. Ibid., 5, 99; "United States Nuclear Tests: July 1945 through September 1992," 8-9.

[154] Secretary Wilson Announces Deployment of Nuclear Weapons for Air Defense Purposes and Background Fact Sheet, 22 January 1957; Subject Series, Box 7; White House Central Files (Confidential File), 1953-1961; Eisenhower, Dwight D.: Records

that developmental tests like HA were more important for weapons design than proof tests like JOHN.

At each of the twenty-four nuclear shots of PLUMBBOB, Defense personnel were involved in Exercises DESERT ROCK VII and VIII. For most of the shots this involvement was limited to observation and training programs, but at shots BOLTZMANN and WILSON there were evaluations of decontamination equipment; at shot PRISCILLA, various emplacements, foxholes and trenches were subjected to overpressure and bombs, rockets, artillery shells and grenades were exposed to the blast to determine the effect of radiation on fuses; and at shots FRANKLIN, LASSEN, WILSON and HOOD, armoured vehicles were evaluated for protection from radiation.[155] Shots HOOD and SMOKY, the two highest yield shots of the series, also involved troop manoeuvres and a mock helicopter assault on a position near ground zero.[156]

The RAINIER shot of September was the first nuclear test wholly contained underground and was conducted, as Strauss wrote, "to explore this manner of testing [deep underground]."[157] RAINIER was fired inside a tunnel dug horizontally into a mountain – it detonated 899 feet (274 metres) underground and as close as 790 feet (240 metres) from the surface of the slope.[158] It yielded 1.7 kilotons, and completely collapsed the tunnel in which it had been placed, thus containing the blast and

as President; Dwight D. Eisenhower Library.

[155] Harris, "PLUMBBOB Series, 1957," 81-93.

[156] Ibid., 99-100.

[157] Letter from Lewis Strauss to President Eisenhower, 21 December 1956; Administration Series, Box 4; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

[158] Jeannie and Ponton Massie, Jean, "Shots WHEELER to MORGAN, The Final Eight Tests of the PLUMBBOB Series, 6 September - 7 October 1957," in *United States Atmospheric Nucleaer Weapons Tests Nuclear Test Personnel Review* (Washington, D.C.: Defense Nuclear Agency, 1981), 76.

resulting radiation.[159] It was the most advanced underground test yet conducted by the United States – far deeper than TEAPOT ESS or JANGLE UNCLE – and arguably the first true underground shot in so far as the explosion was entirely contained rather than a shallow cratering experiment. The exploration of underground testing came at a critical time, as PLUMBBOB RAINIER contributed important information regarding the ability to detect underground tests and undermined concurrent efforts toward a test ban. Because of its importance in the negotiation of a test ban, RAINIER will be further studied in Chapter Four.

PLUMBBOB was held at a time of particular pressure for Eisenhower and his administration. In August, while only halfway through the test series, the United States proposed a two-year ban on nuclear testing – but connected the ban to a freeze in production of fissile material that was rejected by the Soviet Union. In September, federal troops intervened in Little Rock, Arkansas. And, in October, the Soviet Union launched Sputnik, threatening the military and scientific leadership of the United States. Although PLUMBOB was part of this array of issues facing the Eisenhower Administration in 1957, the confluence of these domestic and international pressures eclipsed PLUMBBOB in contemporary significance. The PLUMBBOB series, then, perhaps as no other, reminds us that nuclear testing was only a part of a wider system of interconnecting problems that the president faced at any given time.

HARDTACK I

Operation HARDTACK Phase I, or HARDTACK I, was the final test series held at Bikini and Eniwetok Atolls in the Pacific, and involved thirty-four nuclear shots held between April and August 1958 that varied greatly in yield and type.

[159] Ibid.

HARDTACK I also included three shots of Operation NEWSREEL, a high-altitude, weapons effects series performed by the Department of Defense. In terms of scale, HARDTACK I was the crescendo of nuclear testing during the Eisenhower Administration.

Eisenhower's reactions to HARDTACK are particularly interesting, and speak more eloquently to his reluctance to conduct large nuclear tests than any so far related. The president expressed his reluctance early in the planning of HARDTACK during a conference with the secretary of state and the national security advisor held in August 1957, while PLUMBBOB was being held in Nevada.[160] Eisenhower questioned the length of HARDTACK – "why was it necessary to have so many shots? Could the series not be limited to not over twelve or so?"[161] – at a time when HARDTACK was planned as twenty-five to twenty-six shots, rather than the thirty-four that eventuated. Eisenhower suspected that "these tests will continue for a longer and longer period of time" and that there would be "difficulty in appearing honest before the world while carrying on such long drawn-out tests."[162] When Lewis Strauss joined the conference later that day, Eisenhower "urged Admiral Strauss to try to fire the test shots in a shorter period."[163]

[160] Also attending this meeting were the president's son, Major John S. D. Eisenhower, and Dulles' special assistant for atomic energy matters, Gerard Smith.
[161] Morning Conference on August 9, 1957; Special Assistant Series, Subject Subseries, Box 1; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.
[162] Ibid.
[163] Afternoon Conference on August 9, 1957; Special Assistant Series, Subject Subseries, Box 1; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library. Eisenhower concluded the morning meeting when he "indicated strongly that he would like to curtail the length of the testing period and the number of test shots." Morning Conference on August 9, 1957; as above.

Strauss responded by outlining the rationale for the scope of HARDTACK. He explained that the number of shots for the series – at that time twenty-five, which the president thought was too high – "had been arrived at arbitrarily."[164] Each of the two nuclear laboratories (Los Alamos and Lawrence Livermore) requested twenty shots and the Department of Defense requested ten, a figure that Strauss had, "at first glance, cut in half."[165] It was this rationale, along with mention of the test of a thermonuclear bomb of such high yield as to rival CASTLE BRAVO, that led Eisenhower to lament "our statecraft was becoming too much a prisoner of our scientists."[166]

To be fair, much of the reluctance Eisenhower showed toward HARDTACK was related less to testing as it was to testing while negotiating a test ban with the Soviet Union. The president said as much in the meetings of 9 August 1957: he "felt that an excessive amount of time consumed in testing served to magnify our efforts to the world at a time when disarmament negotiations are under way."[167] Eisenhower

[164] Memorandum of Conference with the President, August 9, 1957 – 2:30 PM; Subject Series, Alphabetical Subseries, Box 3; White House Office: Office of the Staff Secretary, 1952-1961; Dwight D. Eisenhower Library.
[165] Ibid. Strauss also explained that he "had every intention" of reducing the scope of HARDTACK below twenty-five shots, which of course did not happen.
[166] Afternoon Conference on August 9, 1957; Special Assistant Series, Subject Subseries, Box 1; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library. Eisenhower returned to this theme in his farewell speech of 1961, saying that "in holding scientific research in respect…we must also be alert to the equal and opposite danger that public policy could itself become the captive of a scientific-technological elite." Paul Rubinson, "'Crucified on a Cross of Atoms': Scientists, Politics, and the Test Ban Treaty," *Diplomatic History* 35, no. 2 (2011): 305. Greene convincingly argues that Eisenhower was always skeptical of scientists, either because they "drew political conclusions from their inventions" or, in this case, because their discoveries led to more dangerous weapons. Greene, *Eisenhower, Science Advice, and the Nuclear Test Ban Debate, 1945-1963*: 23-24.
[167] Memorandum of Conference with the President, August 9, 1957 – 2:30 PM;

was more explicit in a conference with the secretary of defense one week later. His comments are worth quoting in full:

> When [Secretary] Wilson brought up the subject of Operation HARDTACK, the President stated that *this subject has him in a more awkward position than any other he can think of*. Here he is talking disarmament and at the same time planning a four-month period of atomic weapons testing which will involve twenty five shots.[168]

HARDTACK was kept within a period of four months but increased in extent to thirty-four shots – this despite Strauss's "every intention" to reduce the number of shots. Eisenhower and Strauss noted that the scope of HARDTACK affected the test ban negotiations such that the position of the United States "must be that we cannot suspend testing until a date at least a year from now."[169]

The HARDTACK series featured seven megaton-range tests, including HARDTACK POPLAR of 9.3 megatons of TNT equivalent, the fifth highest yield test ever held by the United States.[170] Neither the AEC nor the State Department could justify the testing of high yield weapons; this requirement came from the Department of Defense, which was "interested in ascertaining the size of yield which may be carried in the B-52 [bomber]."[171] Strauss suggested, and Eisenhower agreed

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Subject Series, Alphabetical Subseries, Box 3; White House Office: Office of the Staff Secretary, 1952-1961; Dwight D. Eisenhower Library.

[168] Memorandum of Conference with the President, August 16, 1957; DDE Diary Series, Box 26; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library. Emphasis is my own.

[169] Memorandum of Conference with the President, August 9, 1957 – 2:30 PM; Subject Series, Alphabetical Subseries, Box 3; White House Office: Office of the Staff Secretary, 1952-1961; Dwight D. Eisenhower Library. The test moratorium took effect just over thirteen months after this meeting.

[170] "United States Nuclear Tests: July 1945 through September 1992," 10-13. Ahead of POPLAR were BRAVO, YANKEE and ROMEO of Operation CASTLE and MIKE of Operation IVY.

[171] Memorandum of Conference with the President, August 9, 1957 – 2:30 PM; Subject Series, Alphabetical Subseries, Box 3; White House Office: Office of the

as one of the conditions for his approval of the series, that no weapons be tested with a yield higher than "the 1954 test" – that is, the 15 megatons of CASTLE BRAVO.[172] (This was a particularly misleading compromise that Strauss had offered: as we have seen, the high yield of BRAVO was achieved mostly through error and accident, and was intended to yield only 5 megatons. HARDTACK POPLAR rivalled the yields intended and achieved in shots such as CASTLE ROMEO.) The testing of high-yield devices raised the issue of fallout that Strauss addressed three months later. While the specifics remain redacted, it is clear that even at an early stage of planning, when twenty-three tests were anticipated, HARDTACK was expected to make a "slightly greater" contribution to world-wide fallout than Operation REDWING of 1956 but far less than Operation CASTLE.[173] While HARDTACK was underway, Eisenhower learned from Hans Bethe, a physicist who made crucial contributions to the development of the hydrogen bomb and member of the President' Science Advisory Committee, that the Soviet experience of fallout was far worse than the American, although this seems not to have relieved the president.[174]

Most notable of the extensive HARDTACK series of shots were those that made up Operation NEWSREEL, a weapons effects study by the Department of Defense conducted at high altitude. These three shots were fired "to test [the United

Staff Secretary, 1952-1961; Dwight D. Eisenhower Library

[172] Ibid.

[173] The increase in global fallout over REDWING was due mostly to TEAK and ORANGE, multi-megaton shots fired at high altitude where "all of the fission yield is presumably deposited world-wide." Letter from Lewis Strauss to President Eisenhower, 23 November 1957; Administration Series, Box 5; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

[174] Memorandum of Conference with the President, June 18, 1958, 11:45; DDE Diary Series, Box 33; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

States'] capability to detect nuclear detonations [at high altitude] and to obtain effects information applicable to high-altitude missile and counter-missile programs."[175] Shot YUCCA began HARDTACK on 28 April and was fired from a balloon at an altitude of 86,000 feet (26,212 metres) above Eniwetok Atoll.[176] YUCCA had a similar yield to the preceding high-altitude shots, TEAPOT HA and PLUMBBOB JOHN, at 1.7 kilotons of TNT equivalent but was held at far higher an altitude than those other shots.[177] Shots TEAK and ORANGE, the dramatic conclusion to HARDTACK in August, were of much greater yield and fired at a much greater altitude. Both devices were fired from rockets and both yielded 3.8 megatons; TEAK detonated at an altitude of 252,000 feet (76,809 metres) while ORANGE detonated at 141,000 feet (42,976 metres).[178] Serious concerns about flash blindness, which, because of the altitude of the tests, would affect a great area, forced the tests to be moved from Bikini Atoll to Johnston Island.[179] These concerns were warranted, as experiments at TEAK showed that rabbits endured chorioretinal burns to their eyes at distances "exceeding 480 km [298 miles]."[180]

While the Department of Defense was interested in the effects of flash blindness in high-altitude tests, it was probably more interested in the effects of these

[175] Letter from Lewis Strauss to President Eisenhower, 2 August 1957; Administration Series, Box 5; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.
[176] "United States Nuclear Tests: July 1945 through September 1992," 10-11.
[177] To put this test in context, YUCCA detonated at an altitude similar to the 2013 Chelyabinsk meteor, but the latter was more than two hundred and fifty times more powerful.
[178] Ibid., 12-13.
[179] The concern was for the 11,000 Marshallese who lived within 400 miles (643 kilometres) of Bikini Atoll and who could not be issued dark goggles. Herman Hoerlin, "United States High-Altitude Test Experiences: A Review Emphasizing the Impact on the Environment," (Los Alamos, New Mexico: Los Alamos Scientific Laboratory, 1976), 15.
[180] Ibid., 11.

tests on radio communications. The ionization caused by high-altitude events degraded radio communications through the decay of fission products, which created gamma rays and beta radiation. The extent of this degradation depended upon the location and fission yield of the shot, which is to say that high-yield, high-altitude shots like TEAK and ORANGE had the "most severe" effect.[181] The debris from TEAK rose to an altitude of 500 kilometres [310 miles] in twenty minutes, and the fission products within this debris "were sources of serious communication blackouts in the South Pacific, New Zealand and Australia."[182] ORANGE had a less pronounced but longer-lasting effect on radio communications because of its lower altitude of detonation. Herman Hoerlin, a physicist present on Johnston Island for the TEAK and ORANGE shots, dramatically recalled

> not so much the difficulties encountered by the JI [Johnston Island] communication people in making contact with the outside world but rather the desperate attempts of other transmitting stations to obtain a response from JI. One of the first transmissions actually received at JI in the morning hours after the [TEAK] event was "Are you still there?"[183]

The degrading effect of high altitude explosions on radio communications was of interest to the Department of Defense, because it represented the ability to blackout an enemy's communications and so retard that enemy's military efforts. James Killian, special assistant for science and technology to President Eisenhower, anticipated that the phenomena associated with high-altitude nuclear explosions "may affect the entire NIKE-ZEUS program [an anti-ICBM missile system]" although the effects to which Killian referred were more readily studied in Operation ARGUS.[184]

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[181] Ibid., 17.
[182] This blackout affected medium and high frequency radio communication. Ibid.
[183] Ibid., 18.
[184] Memorandum of Conference with the President, March 6, 1958, 3 PM; DDE Diary Series, Box 31; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

Indeed, both of the effects observed in the HARDTACK shots – flash blindness and radio interference – were further explored in the subsequent ARGUS and later DOMINIC series of tests.

Also scheduled for HARDTACK was a single high-yield, "clean" shot that was to be observed by the United Nations. This was a controversial test, and the road to its cancellation was paved by revealing debate within the Eisenhower Administration. Eisenhower appears to have been informed of this "clean" test in November of 1957, and Strauss noted that the "matter is under intensive study and you will be asked to review out plans at an early date."[185] More information became available the following March. The AEC and the OCB recommended that an "additional test shot" of a 6 megaton thermonuclear device be appended to HARDTACK, and that "fifteen qualified international scientists selected by the United Nations and a representative group of international news media" be invited to observe this test.[186] Of most concern to the United States Information Agency (USIA), however, was the "cleanliness" of the test. The USIA pointed out that although the president had publicly stated that the test would be 96% "fallout-free," the AEC could not guarantee that figure and, "if it were not possible to achieve such a figure in the test, the backfire from world opinion would be too great to justify having it."[187] Eisenhower nonetheless made a statement to the press the next day outlining

[185] Letter from Lewis Strauss to President Eisenhower, 23 November 1957; Administration Series, Box 5; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

[186] Letter from Robert Cutler to President Eisenhower, 24 March 1958; Administration Series, Box 11; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library. The test was to be conducted in the Pacific, suggesting it would belong to HARDTACK I rather than HARDTACK II.

[187] Part of the division between the AEC and USIA was whether a specific percentage should be outlined in the president's statement – the USIA believed that a percentage

plans for this test, although conspicuously without a percentage qualifying the anticipated reduction in fallout.[188]

The director of the USIA, George V. Allen, wrote a more convincing memorandum opposing the "clean" test four months later. In this letter, Allen framed his opposition in terms of the United States' interests, specifically that the demonstration "would not be likely to achieve the purpose originally intended."[189] Most importantly, Allen identified reasons close to Eisenhower's own thinking: that it was "preferable for [the United States] to avoid actions which might be construed as antagonistic to the basic purpose of the Geneva talks."[190] The cancellation of the "clean" test was put in these terms by the new secretary of defense, Neil McElroy, and the new chairman of the AEC, John McCone, in August: "In view of the proposed suspension of testing, it does not seem appropriate to continue work on the announced laboratory demonstration scheduled for this autumn."[191] It is possible that the shot

must be given, while the AEC disagreed. Memorandum for General Cutler from Roy M. Melbourne, 25 March 1958; NSC Series, Briefing Notes Subseries, Box 2; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library and Memorandum for General Cutler from Abbott Washburn, 25 March 1958; NSC Series, Briefing Notes Subseries, Box 2; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.

[188] Statement by the President, 26 March 1958; NSC Series, Briefing Notes Subseries, Box 2; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.

[189] Memorandum for Members of the Operations Coordinating Board, 23 July 1958; NSC Series, Briefing Notes Subseries, Box 2; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.

[190] Allen also suggested that the "focus of world attention [is] on the Middle East," presumably referring to the concurrent U.S. intervention in Lebanon and British intervention in Jordan. Ibid.

[191] The cancellation of the "clean" shot was buried four paragraphs into the statement by McElroy and McCone. Plans for the Conclusion of U.S. 1958 Test Program, 26 August 1958; OCB Series, Subject Subseries, Box 5; Office of the Special Assistant

was cancelled because the United States ran out of time before the beginning of the moratorium, although for reasons identified in the following sections dedicated to ARGUS and HARDTACK II this is unlikely; moreover, Eisenhower cancelled at least one other shot because of the "impressions gained in Geneva" rather than the pressures of the 31 October deadline.[192]

HARDTACK I was something of an apogee for nuclear testing during the Eisenhower years – comprising the second highest yield and number of shots of the ten series held between 1952 and 1958. It included three important high-altitude tests as well as a variety of surface shots. HARDTACK, like UPSHOT-KNOTHOLE, also saw the transition between chairmen of the AEC, as Lewis Strauss – who had dominated atomic energy policy during his tenure – stepped aside for John McCone.[193]

Most interesting of HARDTACK I, however, were the shots that were *not* held – which acted as exemplars of the discursive interaction between the drive to test

for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.

[192] The best information about this second cancelled shot comes from Gordon Gray, Eisenhower's National Security Advisor. This additional shot was proposed after HARDTACK I had completed and was immediately opposed by the State Department. Gray sought Eisenhower's approval but was met with "some irritation" from the president, who said that "he had announced the [test] suspension and now 'they' wanted to have another big test." Discussion among the President's science advisors, the chairman of the Joint Chiefs of Staff, John McCone and Neil McElroy led to this test being "waived" because "it would be undesirable to have a large test before October 31st [the start of the test moratorium]." Memorandum for the Record, 27 August 1958; Special Assistant Series, Presidential Subseries, Box 3; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.

[193] John McCone was later brought in, as an example of bipartisanship, to the Kennedy Administration as Director of Central Intelligence, a role that also included him in the Executive Committee of the National Security Council during the Cuban Missile Crisis of October 1962.

and the awareness of the forthcoming test moratorium. These two forces were held in tension by, on the one hand, the AEC and Department of Defense, and on the other, the State Department, the USIA, and Eisenhower himself. This tension was a defining feature of HARDTACK, and played out in internal debate about the scope and length of the test series; it will be further discussed in Chapter Five.

The weapons effects tests of shots YUCCA, TEAK and ORANGE provided important information regarding high-altitude nuclear detonations, and led directly to the subsequent series, Operation ARGUS.

ARGUS

Operation ARGUS was conducted in the South Atlantic Ocean during late August and early September 1958 and included three high-altitude shots. It was the first test series conducted for purely weapons effects purposes since CROSSROADS of 1946. ARGUS was also the first post-war series that was not previously announced by the United States and was held in complete secrecy.[194] This series was notable for many reasons, foremost that it “not only provided data on military considerations but also produced a great mass of geophysical data, pure scientific material of great value.”[195] Indeed, ARGUS was described by the *New York Times* as “the greatest

[194] ARGUS was kept so secret because its effects were global, and could be observed by any nation; “the most obvious way to prevent other nations from acquiring experimental data was to deny them accurate knowledge of the operation’s timing and objectives.” The White House rationalized this secrecy by adopting the “line” that ARGUS was part of HARDTACK, and that it had never been the United States’ policy to announce every shot of a series. C.B. Jones, et. al., "Operation ARGUS 1958," in *United States Atmospheric Nuclear Weapons Tests Nuclear Test Personnel Review* (Washington, D.C.: Defense Nuclear Agency, 1982), 18.

[195] Ibid., 2. This data included “the first extensive experimental evidence concerning the structure of the earth’s [sic] magnetic field above a thousand miles or so.” Memorandum for the President from J.R. Killian Jr., 3 November 1958; Office of the

scientific experiment ever conducted" and by James Killian as "probably the most spectacular ever conducted."[196]

ARGUS was rushed by the forthcoming test moratorium. A memorandum from the assistant to the secretary of defense described this with some incongruity: "The possibility that events in the near future may create conditions unfavourable to the continuation of nuclear tests…lends urgency to the accomplishment of an important experimental program now under development."[197] Admiral Mustin Lloyd, the commander of the ARGUS taskforce, reported that a "sense of urgency was injected into this planning due to the political climate then prevailing, which rendered the future of nuclear testing politically uncertain."[198] As a result, ARGUS was "one of the most expeditiously planned and executed" of all U.S. test series – the period of five months from inception to execution contrasted with the "one or more years" of planning for other series.[199]

Special Assistant for Science and Technology Policy (James R. Killian and George B. Kistiakowsky): Records, 1957-1961, Box 1; White House Office; Dwight D. Eisenhower Library.

[196] This headline from the *New York Times* was from March 1959 after information about ARGUS had been leaked to that publication, incurring Eisenhower's "vehemence." Ibid., 12.

[197] Memorandum for Brig. Gen. A. D. Starbird, et. al. from Herbert B. Loper, 21 April 1958; Office of the Special Assistant for Science and Technology (Jame R. Killian and George B. Kistiakowsky): Records, 1957-1961, Box 1; White House Office; Dwight D. Eisenhower Library.

[198] Jones, "Operation ARGUS 1958," 18.

[199] Jones, "Operation ARGUS 1958," 11. Killian noted that this five-month period also involved the launch and coordination of the Explorer IV satellite for measurements – a not unimpressive accomplishment at the infancy of the U.S. space program. Memorandum for the President from J.R. Killian, Jr., 3 November 1958; Office of the Special Assistant for Science and Technology (Jame R. Killian and George B. Kistiakowsky): Records, 1957-1961, Box 1; White House Office; Dwight D. Eisenhower Library. Following the memorandum of 21 April 1958, Eisenhower approved ARGUS on 1 May. Memorandum of Conference with the President, May 1, 1958; Subject Series, Alphabetical Subseries, Box 3; White House Office: Office of

From a position in the South Atlantic a task group of U.S. ships made three launches of missiles carrying nuclear warheads into the upper atmosphere. The yield of these warheads was between 1 and 2 kilotons.[200] The detonations varied in altitude between 124 miles (200 kilometres) for ARGUS I and 335 miles (540 kilometres) for ARGUS III.[201] The ARGUS shots were the highest altitude shots conducted by the United States until that time, and ARGUS III remains the highest altitude shot ever fired by the United States.[202] Each detonation produced a fireball of “expanding, glowing” debris that was “confined and guided” by the Earth’s magnetic field along magnetic field lines.[203] Half of this material plunged down atop the atmosphere while the other half arched across the equator over 4,000 miles (6,440 kilometres) to intersect again with the Earth near the Azores Islands. At both points, in the South and North Atlantic, U.S. Navy ships observed aurorae and radar reflections.

ARGUS produced effects of profound military importance. These included the “absorption and reflection of radio waves and radar beams.”[204] This effect was a further development over the results of HARDTACK TEAK and ORANGE and was “important for space warfare.”[205] A new feature over those previous tests was that the

the Staff Secretary, 1952-1961; Dwight D. Eisenhower Library.

[200] "United States Nuclear Tests: July 1945 through September 1992," 12-13.

[201] Hoerlin, "United States High-Altitude Test Experiences: A Review Emphasizing the Impact on the Environment," 4.

[202] The STARFISH shot of Operation DOMINIC was detonated at a higher altitude than ARGUS I and ARGUS II.

[203] Memorandum for the President from J.R. Killian, Jr., 3 November 1958; Office of the Special Assistant for Science and Technology (Jame R. Killian and George B. Kistiakowsky): Records, 1957-1961, Box 1; White House Office; Dwight D. Eisenhower Library.

[204] Effects of Nuclear Weapon Explosions in the Outer Atmosphere, A Brief Status Report, 24 July 1958; Office of the Special Assistant for Science and Technology (Jame R. Killian and George B. Kistiakowsky): Records, 1957-1961, Box 1; White House Office; Dwight D. Eisenhower Library.

[205] Ibid.

debris of the ARGUS tests formed an area several hundred kilometres across and above an altitude of 70 miles (112 kilometres) that, in addition to interfering with radio communications, also reflected radar. This effect was particularly consequential for the design of both ballistic missiles, which would penetrate such an area, and anti-missile defensive batteries, which might intercept incoming missiles at that altitude.

The layer of high-energy electrons created by the ARGUS shots also posed a threat to space vehicles. This effect could damage or disable both ballistic missiles and satellites, and threatened manned space flight.[206] ARGUS demonstrated that "a small number of megatons exploded at a suitably high altitude can make manned space flight impossible for a period of time which [had] not yet been precisely determined but may be as long as several months."[207] Recall that, in 1958, the year following Sputnik, the United States was perceived to be losing the space race – this should not be forgotten when one notes that ARGUS established the United States' ability to imperil satellites and manned spacecraft.

ARGUS also further developed the optical effects experiments of HARDTACK I. It was determined that roughly 20% of the yield of a device detonated in the upper atmosphere might be emitted in the optical band, although the brightness of the blast would be determined by its altitude.[208] At 500 miles (800 kilometres) distance, the light from a one-megaton detonation in its first millisecond was determined to be about twenty times stronger than direct sunlight over a similar period.[209] HARDTACK TEAK had caused permanent retinal damage at a distance of

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[206] None of the ARGUS shots did damage a satellite, although DOMINIC STARFISH disabled multiple satellites in 1962. See Chapter Five.
[207] Ibid.
[208] Ibid.
[209] Effect on the Ground, undated; NSC Series, Briefing Subseries, Box 2; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House

300 miles (480 kilometres). The optical effect of a high-altitude detonation tapered off at an altitude over 200 miles (320 kilometres), but between 50 and 200 miles there was an indeterminate point where yield and altitude of blast would produce permanent damage to the eye over the greatest possible area.[210]

The various weapons effects observed in the ARGUS series – radar reflection, radio absorption, high-energy electrons and flash blindness – significantly affected many weapons systems. These included: all anti-ballistic missile systems; some radar and communications equipment; Strategic Air Command communications, including the SAC recall system; satellites and manned space vehicles; and all aircraft, whose pilots were vulnerable to intense optical flash.[211] The extent to which ARGUS influenced these weapons systems speaks to its importance as a test series, as it does to the necessity to, if hastily, conduct these experiments before the test moratorium took effect. Expedited though ARGUS was, it was not the last series to be conducted by the United States before the moratorium – Operation HARDTACK Phase II began six days after ARGUS III.

HARDTACK II

Operation HARDTACK Phase II, or HARDTACK II, was the final test series held before the test moratorium took effect on 31 October 1958 and was thus the final test series to be conducted during the Eisenhower Administration. HARDTACK II

Office; Dwight D. Eisenhower Library.

[210] In the aforementioned example of a one megaton bomb visible at 500 miles, the altitude required to affect such an area was only 200,000 feet, or 61 kilometres. Ibid and Effects of Nuclear Weapon Explosions in the Outer Atmosphere, A Brief Status Report, 24 July 1958; Office of the Special Assistant for Science and Technology (Jame R. Killian and George B. Kistiakowsky): Records, 1957-1961, Box 1; White House Office; Dwight D. Eisenhower Library.

[211] Ibid.

was held at the Nevada Test Site during August and October, and – although a smaller program than PLUMBBOB – it was an extension of "PLUMBBOB studies and subsequent laboratory research."[212] The tests that comprised HARDTACK II continued up until 30 October 1958, one day before the moratorium came into effect, and the test program was designed "to provide data for continuation of long range programs which otherwise might have been terminated or seriously handicapped by a moratorium on weapon tests."[213] In other words, HARDTACK II was to furnish data that could be studied during the moratorium.

It is the relationship between this series and the imminent test moratorium, rather than the tests themselves, that distinguishes HARDTACK II. Documented above was the rushed nature of the penultimate Operation ARGUS; as the final series before the moratorium, the program for HARDTACK II was even more accelerated. The press as a result nicknamed the series "Operation Deadline."[214] In approximately six weeks, the United States conducted thirty-six shots, although half of these were safety experiments of negligible yield.[215] HARDTACK II was inescapably hurried because the number of shots allocated to the series increased even after the series began, and it is this acceleration that is most remarkable about HARDTACK II.

HARDTACK II was first put to Eisenhower by Lewis Strauss in November 1957. Although not yet named or even envisioned as a separate phase of the HARDTACK series, Strauss sought permission to fire "two or three very small yield

[212] Operation HARDTACK – PHASE II, Civil Effects Test Operation, Project Summaries, 22 September 1958; NSC Series, Briefing Note Subseries, Box 3; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.
[213] Ibid.
[214] Greene, *Eisenhower, Science Advice, and the Nuclear Test Ban Debate, 1945-1963*: 165.
[215] "United States Nuclear Tests: July 1945 through September 1992," 12-17.

nuclear shots" at the Nevada site "after HARDTACK had been completed."[216] That these shots were to be fired at Nevada, rather than in the Pacific alongside the other shots of HARDTACK I, "was in the interest of reducing to a minimum the number of shots in HARDTACK."[217] Strauss' rationale was precarious, but it is unclear if Eisenhower saw it as such. Strauss was more specific the following January when he requested approval for "some two to ten safety tests" to be conducted at Nevada.[218] Eisenhower approved what was HARDTACK I along with what would be HARDTACK II on 31 January 1958.[219]

More information became available in June. Strauss in writing and in a meeting requested approval for additional shots for HARDTACK II (although how many Strauss requested is not known). It was then known as MILLRACE, and in endorsing preparations for the series, Eisenhower insisted that it be brought forward "so that at the end of August…[Strauss] could fly people back from the Pacific [from HARDTACK I], with preparations already made in Nevada so that the tests could continue without interruption."[220] Eisenhower anticipated the commencement of the

[216] Letter from Lewis Strauss to President Eisenhower, 23 November 1957; Administration Series, Box 5; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.
[217] Ibid.
[218] Letter from Lewis Strauss to President Eisenhower, 29 January 1958; Subject Series, Alphabetical Subseries, Box 5; White House Office: Office of the Staff Secretary, 1952-1961; Dwight D. Eisenhower Library.
[219] Endorsement, 31 January 1958; Subject Series, Box 9; White House Central Files (Confidential File), 1953-1961; Eisenhower, Dwight D.: Records as President; Dwight D. Eisenhower Library.
[220] Memorandum of Conference with the President, 13 June 1958; DDE Diary Series, Box 33; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

moratorium: he told Strauss that tests could continue into September or October but that "the same would not be true if we went into November."[221]

The AEC publicly announced HARDTACK II one month before it began. In that statement, an unspecified but "limited number" of shots were acknowledged.[222] These shots were described as underground tests which gives some clue to the planned extent of the series at that time – only twelve shots of the series were held in shafts or tunnels.[223] However, the AEC statement articulated purposes for the series beyond the safety tests that Strauss had requested in January, purposes that correspondingly spoke to a widening of scope for the series.[224]

This widened scope was confirmed in a letter to Eisenhower from John McCone less than two weeks before HARDTACK II began. "In light of the anticipated test suspension," McCone wrote, "the AEC and Department of Defense have reviewed weapons development requirements" and "determined that certain test shots…would be essential to the advancement of our weapons technology."[225] McCone requested approval for nine nuclear detonations and seven safety tests.[226] This number increased again three days before the first test when at least two nuclear shots and two safety tests were added.[227] Still more shots were added to HARDTACK

[221] Ibid.
[222] Nuclear Test Series Planned for Nevada Test Site, 8 August 1958; OCB Series, Subject Subseries, Box 5; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.
[223] "United States Nuclear Tests: July 1945 through September 1992," 12-17.
[224] These purposes included weapons development tests and experiments in underground detection. Ibid.
[225] Letter to President Eisenhower from John McCone, 28 August 1958; Subject Series, Alphabetical Subseries, Box 5; White House Office: Office of the Staff Secretary, 1952-1961; Dwight D. Eisenhower Library.
[226] McCone also for the first time referred to the series as "a second phase of HARDTACK." Ibid.
[227] It is difficult to determine the net increase in nuclear shots due to cancellations of

II while it was underway and as the moratorium drew nearer: by 25 October it had grown to nineteen nuclear shots and seventeen safety shots, and a further request on 27 October brought the planned series to twenty nuclear shots and eighteen safety shots.[228] HARDTACK II was far from the two or three shots imagined by Strauss in November 1957, and one wonders at Eisenhower's response to its expansion given his unenthusiastic reaction to the growth of HARDTACK I.

As the last series before the moratorium, HARDTACK II was also the last opportunity that Eisenhower had to observe a nuclear test as president. Recall that Eisenhower had been invited, and declined, to attend UPSHOT ANNIE in 1953 and CASTLE ROMEO in 1954; Divine also suggests that the president had been invited to TEAPOT in 1955.[229] When a reporter asked if Eisenhower would attend REDWING in 1956, the president replied that he did not "believe it was essential that I go…[because] the reports are very detailed."[230] McCone, recognising that HARDTACK II series was "likely to be the last for some time," made invitations to various staff to observe the shots.[231] These invitations were brought up in a meeting

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some shots and redacted sections of this document; nonetheless, it is likely that not less than two nuclear shots were added. Letter to President Eisenhower from John McCone, 9 September 1958; Subject Series, Alphabetical Subseries, Box 5; White House Office: Office of the Staff Secretary, 1952-1961; Dwight D. Eisenhower Library.

[228] Letter to President Eisenhower from John McCone, 27 October 1958; Subject Series, Alphabetical Subseries, Box 5; White House Office: Office of the Staff Secretary, 1952-1961; Dwight D. Eisenhower Library.

[229] Oddly, Divine consistently refers to this series as TEACUP rather than TEAPOT, although this is likely due to the limited access to classified materials at the time Divine was writing. Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960*: 42.

[230] Ibid., 77.

[231] Letter to Gordon Gray from John McCone, 18 September 1958; Special Assistant Series, Subject Subseries, Box 10; White House Office: Office of the Special Assistant for National Security Affairs: Records, 1952-1961; Dwight D. Eisenhower Library.

with the president on 29 September who, quite astonishingly, "expressed envy saying that he had always wanted to see a test but had always been advised that it was unwise."[232] Eisenhower's private confession lends veracity to his public statement in June 1959 that "I just haven't been allowed to go to the tests."[233]

As the final series before the test moratorium took effect on 31 October 1958, HARDTACK II offers a valuable example of nuclear testing within a limited timeframe. The imperative to test weapons did not seem to be opposed by the forces that worked against the expansion of HARDTACK I, and as result the program for HARDTACK II continued to accelerate even as the deadline approached. It is difficult to imagine that, without the imposition of the moratorium, a handful of safety tests could grow into a full-scale test series, but indeed they did, and it was on that cynical note that U.S. nuclear testing during the Eisenhower years ended.

Conclusion

The ten nuclear test series conducted during the Eisenhower Administration led from the development to the deployment of thermonuclear weapons. First proved was the feasibility of a thermonuclear reaction at IVY; then the use of dry fusion fuel at CASTLE; then the ability to deliver such a weapon using an existing strategic platform at REDWING; and, finally, the various possible effects of such weapons at HARDTACK I. Each of these series were rational extensions of the results of

[232] Memorandum of Meeting with the President on 29 September, 3:30 to 4:00 p.m.; Special Assistant Series, Presidential Subseries, Box 3; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.

[233] Official White House Transcript, President Eisenhower's Press and Radio Conference #161, 17 June 1959; Press Conference Series, Box 8; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

previous series, and speak to the continued, essential interest in weapons design tests. It is important to note, however, that once the development and deliverability of thermonuclear weapons had been assured, the emphasis of testing shifted to weapons effects tests, particularly high-altitude effects tests as seen at HARDTACK I and ARGUS.

Of the test series held between 1952 and 1958 Operation CASTLE is conspicuous. CASTLE was by far the highest-yield test series ever held by the United States: its yield alone was greater than the combined yield of all other series held during these years. Its first shot was the largest device ever tested by the United States, and was the worst incident of fallout exposure in the history of U.S. nuclear testing. The importance of CASTLE comes from two interrelated but opposing dimensions: that, first, it was so crucial for the development of thermonuclear weapons while, second, the radiological contamination it caused was the catalyst for the test ban debate.[234]

The results of these test series permitted impressive technical accomplishments in the American nuclear arsenal that corresponded to the aforementioned theoretical developments. Advances in yield-to-weight ratio resulted

[234] Divine gives much credit to the Democratic challenger in the 1956 presidential election, Adlai Stevenson, who campaigned on the issue of a test ban and, although easily defeated by Eisenhower, “brought the test ban out of obscurity and into the forefront of public discussion.” Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960*: 112. While Stevenson’s focus upon the test ban certainly impressed the issue upon the public consciousness, public support for any sort of test ban interestingly and dramatically fell in the months leading up to the 1956 election. The movement of public opinion reflected a constellation of related issues that contributed to Eisenhower’s landslide re-election: “the ‘expert judgment’ of the Administration on an esoteric subject; the Suez crisis and the [Soviet] repression of the Hungarian revolution; and, as a result of these crises, the enhanced role of President Eisenhower as leader of all the people and foremost military expert.” Eugene J. Rosi, "Mass and Attentive Opinion on Nuclear Weapons Tests and Fallout, 1954-1963," *The Public Opinion Quarterly* 29, no. 2 (1965): 282-83.

in the miniaturisation of nuclear warheads: the 10,000-pound (4,535-kilogram) implosion fission bombs of 1949 had by 1954 been superseded by 1,000-pound (453-kilogram) warheads that possessed yields equal to or greater than their larger predecessors.[235] Under Eisenhower, the miniaturisation of warheads and subsequent diversification of delivery systems saw the end of the monopoly held by the strategic bomber – artillery, surface-to-surface rockets, tactical bombers, supersonic high-altitude bombers, submarines and intercontinental ballistic missiles were now also bearers of nuclear warheads. Diversification of delivery systems during the 1950s owed much to the test series held under Eisenhower.

The nuclear test series conducted during the Eisenhower Administration represented the peak of U.S. nuclear testing. Under Eisenhower, nuclear testing was dramatic and extensive, largely because testing had been normalised under Truman and because Eisenhower had inherited from Truman the emphasis on the development of thermonuclear weapons. By comparison, testing under Kennedy was an awkward appendage, limited in scope, and undertaken largely for political rather than developmental purposes. I return to the nuclear test series of the Kennedy Administration in Chapter Five; in the next chapter, I discuss the paradigm of weapons effects tests that had existed as early as CROSSROADS of 1946 but which received greater emphasis in the later series of the Eisenhower Administration.

[235] Rosenberg, "The Origins of Overkill: Nuclear Weapons and American Strategy, 1945-1960," 30.

Chapter Four

The Expansion and then Suspension of Nuclear Testing

"We would know of any explosion which yielded more than 10 KT equivalent, unless the Soviets took the most extraordinary precautions to prevent us learning about a test."

Lewis Strauss, 27 May 1954.

"…the United States has done all that it really needs to do in this field [nuclear testing]…"

French foreign minister Couve de Murville, 21 August 1958.

During the presidency of Dwight D. Eisenhower, the United States strained uneasily in its relationship with nuclear weapons. That the U.S. should possess – and, by extension, test and develop – these weapons was a notion that had been normalised in the preceding years. Within a few years nuclear weapons had become an essential part of both the defense of the nation and its sense of identity. But after the IVY MIKE test of 1952, and especially so after the CASTLE BRAVO test of 1954, the profundity and enormity of thermonuclear weapons came to be more widely understood, and the concerns of radiation, fallout and lifetime dosage crept into a society that was otherwise enjoying a period of relatively peaceful, post-war economic growth. Even as test series were held yearly in Nevada and the Pacific, and within the atmosphere of McCarthyism and its legacy, the United States grappled with the test ban debate as the president sought a path toward disarmament.

When discussing U.S. nuclear testing during the Eisenhower Administration, historians tend to focus upon the test ban debate that resulted in the test moratorium of 1958.[1] This is a deserved focus. The suspension of nuclear testing was an especially important accomplishment of Eisenhower's presidency, which can be more fully appreciated through recognition of the general expansion of U.S. nuclear testing that preceded the moratorium. This specific appreciation is, however, lacking in the literature. This chapter shall discuss the relationship between nuclear testing and the test moratorium and, in so doing, situate the discussion of a test suspension agreement within the context of a remarkable acceleration in U.S. nuclear testing.[2] This seemingly contradictory circumstance – where testing expanded at the same time as efforts to halt that testing – offers an excellent example of Scott D. Sagan's "domestic politics" or "parochial" model for nuclear weapons development.

That the attention of historians such as Robert A. Divine, Benjamin P. Greene and Jacqueline M. Bird is drawn to the domestic politics behind U.S. nuclear weapons

[1] The best examples are the excellent works of Robert Divine and Benjamin Greene. Divine's book *Blowing on the Wind* examines the debate in the public sphere regarding the test ban and, although limited by the classification of archival material at the time he wrote, Divine accurately argues that Eisenhower had long envisioned a nuclear test cessation agreement but his leadership style frustrated that ambition. Benjamin Greene writes more recently and discusses the relationship between the Administration, particularly the president, and the science community – especially in regard to science advice. Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960*. Greene, *Eisenhower, Science Advice, and the Nuclear Test Ban Debate, 1945-1963*. This chapter makes extensive use of the work of Divine and Greene, but focuses particularly on the parochial discourse within the Eisenhower Administration and makes little comment on the president's leadership style or the science advice he received except where it relates to that discourse.

[2] In this chapter, I use the terms "test suspension" and "test cessation." The former refers to the test moratorium, an impermanent agreement to halt testing. The latter refers to the idealised and more comprehensive agreement for which Eisenhower strived but which would not be realized until the Limited Test Ban Treaty of 1963. The term "test ban" refers more generally to both concepts.

and testing policy speaks to the particular importance of that internal debate within the Eisenhower Administration. Sagan's work on the reasons states develop nuclear weapons again lends itself to understanding this internal debate and its relationship to U.S. testing.[3] Sagan offers a model to explain the spread of nuclear weapons which he titles the "domestic politics model" but which I shall refer to as the parochial model.[4] According to this idea, internal actors within a state are able to affect that state's policies through influence of the government. Although Sagan's work relates to the acquisition of nuclear weapons, I argue that his article can be adapted to help explain U.S. nuclear testing specifically. Sagan identifies three potential sources of influence upon nuclear weapons policy within a state, all of which have equivalents within the Eisenhower Administration: the nuclear weapons industry, here the Atomic Energy Commission (AEC); the professional military, here the Joint Chiefs of Staff (JCS); and certain politicians, here the Department of Defense or the Joint Committee on Atomic Energy (JCAE).[5] The tension between the parochial interests of these actors and their opponents within the government is illustrative of the contours of the debate as well as the interests that domestic actors invest nuclear weapons. The debate within the Eisenhower Administration regarding nuclear testing, particularly its cessation, perfectly fits this model of domestic politics and vested, parochial interests.

In Chapter Three, I explored the ten nuclear test series conducted by the United States during the Eisenhower presidency; in this chapter I shall further explore the consequences of these series as seen through the lens of the parochial model. There was a real and vital connection between the domestic politics of the test ban

[3] In Chapter Two, I applied Sagan's "norms model" to the normalization of testing under Truman.
[4] Sagan, "Why Do States Build Nuclear Weapons?: Three Models in Search of a Bomb," 63-73.
[5] Ibid., 63.

debate and the test series that were the subject of that debate, because at least three of these series provided important technical information of relevance to the debate. This information was seized upon by both sides and became a battleground in that parochial struggle. This chapter will be structured thematically rather than chronologically – beginning, first, with a brief examination of the structural and agential reasons for the rapid expansion of U.S. nuclear testing under Eisenhower, and, then, moving to the technical and discursive elements of the test ban debate that delineated the testing policies of the Eisenhower Administration and so aptly express Sagan's parochial model.

Weapons Effects and the Expansion of U.S. Testing

A defining characteristic of U.S. nuclear testing under Eisenhower was its rapid and comprehensive expansion, and this growth was caused foremost by the shifting focus from weapons design to weapons effects tests. This thesis has previously investigated the paradigm of weapons design tests, to which approximately eighty per cent of U.S. nuclear tests under Truman belonged and through which the United States had developed the hydrogen bomb by 1952. The Eisenhower Administration inherited this focus on weapons design tests, and although these continued under Eisenhower, they received less focus, and tests conducted to examine and understand the effects of nuclear weapons began to supplement tests conducted to prove new design concepts. While these two purposes coexisted together, the increased demand for nuclear testing from the AEC and Department of Defense drove an overall expansion in both the number of nuclear tests and the scope of individual test series.

Of the roughly 150 nuclear tests carried out while Eisenhower was president (a total number complicated by the number of non-nuclear safety shots that were contained within these series) at least fifteen were explicitly for weapons effects purposes.[6] This may seem a slight number but as was noted in previous chapters many U.S. nuclear tests included secondary objectives related to effects studies. An example of these mixed objective were the shots of the various DESERT ROCK exercises, many of which are referred to by the Department of Energy as weapons development tests, but which clearly involved effect studies and military training exercises. Whether as secondary objectives or particularly as the primary purpose of a test, the inclusion of weapons effects tests interfered with weapons design tests. This interference was caused by the growing complexity of effects experiments, and, beginning with Operations TEAPOT and WIGWAM in 1955, the Department of Defense began to sponsor test shots “expressly” for the purpose of effects testing.[7] Nonetheless, interference continued, because in some cases the requirements of weapons design and weapons effects tests were mutually exclusive, and by the time of the moratorium it was recommended that effects and design tests be “conducted separately in both time and place.”[8] As the scope of testing under Eisenhower widened to include weapons design, weapons effects, training exercises and safety tests, there was a gradual dilution of the weapons design paradigm but – most importantly – because of the interference of these competing purposes there was also a general and steady expansion in U.S. nuclear testing. The incompatibility of the

[6] "United States Nuclear Tests: July 1945 through September 1992," 4-17.

[7] L.H. Berkhouse, et al., "Operation DOMINIC I - 1962," in *United States Atmospheric Nuclear Weapons Tests Nuclear Test Personnel Review* (Washington, D.C.: Defense Nuclear Agency, 1983), 140.

[8] This recommendation was borne out in the DOMINIC tests of 1962. Ibid.

various objectives of testing acted to generate more individual nuclear tests to accommodate each of these objectives.

The technological and technical achievements of the weapons design paradigm of testing have already been explored.[9] By the time of the test moratorium in 1958 the United States had developed and refined the fusion bomb, miniaturised both it and its fission predecessor, and proven its ability to deliver nuclear weapons by rocket, missile, strategic bomber and even artillery. Just as significant as these achievements was the United States' increasingly sophisticated understanding of nuclear weapons effects. Weapons effects tests studied

> the effects of detonations on military systems…[including]…measurements of how the nuclear burst altered the environment in which the military system operated, and…the performance or survival of the military equipment or system itself during and following direct exposure to the detonation.[10]

Most obvious of these effects were those related to airburst detonations, which evolved eventually into high-altitude detonations. Airbursts involved the detonation of a nuclear weapon at certain height above the surface. The military advantages of an airburst – which exposed a larger area to more destructive blast effects than a surface burst – were immediately apparent, and both the Hiroshima and Nagasaki devices were detonated as airbursts. There were also advantages for using airbursts during testing. Detonations at altitude produced less fallout, because fallout was partly generated through the contact of the nuclear fireball with the surface, which drew up large quantities of material into the bomb cloud that were then irradiated and dispersed. Several weapons design tests under Truman, foremost Operation RANGER, involved airdrops but the weapons effects studies of Operation BUSTER-

[9] See Chapter Two, which discusses the weapons design paradigm explicitly. Chapter Three concluded with a discussion on the diversification of nuclear weapons during Eisenhower's presidency.
[10] Berkhouse, "Operation DOMINIC I - 1962," 31.

JANGLE specifically measured the blast overpressures generated by airburst weapons and these latter tests profoundly affected contemporary plans for the use of nuclear weapons.[11] Probably more so than CROSSROADS, BUSTER-JANGLE were the most crucial effects studies of the Truman period because they revealed miscalculations of blast pressures that could only have been understood through effects testing.

As technology and doctrine evolved, airbursts became of particular interest for the interception of aerial targets – first, of formations of enemy bombers and, then, as an anti-missile missile. Correspondingly, weapons effects tests moved from airburst to high altitude shots and, eventually, exoatmospheric tests. The first high altitude shot was conducted as part of Operation TEAPOT in 1955, and a proof test of an air-to-air missile developed from the results of TEAPOT was held at PLUMBBOB in 1957.[12] In the following year, three high altitude shots – two of which were of megaton-yield – were fired as part of Operation HARDTACK Phase I, and a further three exoatmospheric shots were fired as part of Project ARGUS. Rather than raw effects data such as blast as a function of yield and altitude, these high altitude shots produced important information regarding electromagnetic effect on radio communications, radar blackouts, and radiation damage to spacecraft and satellites. Shots TEAK and ORANGE of Operation HARDTACK I created extensive radio blackouts as a result of the debris from the test and the gamma rays generated by this debris. Communications at Johnston Island were "cut off for many hours," civilian air traffic to and from Hawaii was suspended for a similar period because of interrupted radio communications, and New Zealand and Australia experienced radio blackouts in

[11] See Chapter One.
[12] See Chapter Three.

the medium and high frequency ranges.[13] The movement of high-energy electrons produced by the ARGUS space tests produced disruptive radio noise, and the interaction of these effects with the Earth's ionosphere created radar reflections.[14] Together with the absorption of radio waves, these radar reflections were described as the "most important effects" of exoatmospheric shots because they represented the ability to blackout an enemy's radar prior to an attack so as to aid penetration of that enemy's air defenses (during the Kennedy Administration, nuclear detonations used to this effect would be known as "precursor bursts").[15] Finally, both HARDTACK I and ARGUS shots produced belts of trapped radiation within the Earth's magnetic field that both damaged unprotected space vehicles (such as satellites or re-entering ICBMs) and was potentially lethal to astronauts. Such was the concern about the latter effect that James Webb, the director of the National Aeronautics and Space Administration, later prevailed upon President Kennedy to restrict tests in 1962 to lower altitudes.[16] These phenomena were crucial because they showed that, in addition to their raw destructive power, nuclear weapons could be used in high-altitude detonations to retard an enemy's ability to communicate with his forces, his ability to detect and intercept attack, and could even serve defensively to knockout

[13] Hoerlin, "United States High-Altitude Test Experiences: A Review Emphasizing the Impact on the Environment," 17-18.
[14] Memorandum for the President from James R. Killian, Jr., 3 November 1958; Office of the Special Assistant for Science and Technology (James R. Killian and George B. Kistiakowsky): Records, 1957-1961, Box 1; White House Office; Dwight D. Eisenhower Library.
[15] Effects of Nuclear Weapon Explosions in the Outer Atmosphere, a Brief Status Report, 24 July 1958; Office of the Special Assistant for Science and Technology (James R. Killian and George B. Kistiakowsky): Records, 1957-1961, Box 1; White House Office; Dwight D. Eisenhower Library.
[16] Hoerlin is critical of this "highly emotional" appeal and blames it for the cancellation of DOMINIC URRACA. The cancellation of URRACA will be explored in Chapter Five. Hoerlin, "United States High-Altitude Test Experiences: A Review Emphasizing the Impact on the Environment," 46.

communications or spy satellites and potentially damage, dilute or destroy an incoming missile attack. Weapons effects testing not only confirmed these abilities but also measured their extent so that they could be integrated into detailed plans for the use of nuclear weapons.

Complementary to the structural momentum for expansion found in diversified reasons for testing was a far more agential one: Lewis Strauss.[17] Greene is particularly critical of the chairman of the AEC for the offences of "over-selling" concepts like the clean bomb, restricting advice that the president received, and even "red-baiting" test ban advocates like Hans Bethe.[18] That Strauss sought to protect U.S. testing from a cessation agreement is indisputable. As part of that defense, Strauss also had some responsibility for the expansion of U.S. nuclear testing, specifically in the number and/or yield of shots conducted within certain series – here I am thinking particularly of Operation HARDTACK Phase I, which Strauss set "arbitrarily" at twenty-five shots but which despite his "every intention" grew to thirty-four shots, including seven multi-megaton shots.[19] This series offers a pointed example of the parochial interests of an actor within a government working to influence testing policy: in this case the chairman of the AEC, with little subtlety but with much agency, consistently increasing the scope of a particular test series. Strauss's actions in relation to HARDTACK I, but also to nuclear testing generally during his tenure, bear out Sagan's parochial model.

[17] Strauss's determination to extensively test nuclear weapons can be partly explained by his deep opposition to communism. For a useful source on Strauss, see Richard Pfau, *No Sacrifice Too Great: The Life of Lewis Strauss* (Charlottesville: University Press of Virgina, 1984.

[18] Greene, *Eisenhower, Science Advice, and the Nuclear Test Ban Debate, 1945-1963*: 127. For more on the tribulations of Hans Bethe, see Jacqueline M. Bird, *Scientists in Conflict: Hans Bethe, Edward Teller and the Shaping of United States Nuclear Weapons Policy 1945-1972* (Claremont: Regina Books, 2008).

[19] See Chapter Three.

The progression from the normalisation of nuclear testing under Truman to its expansion under Eisenhower was for the most part organic. Once the possession of weapons and the act of testing those weapons was normalised and even accepted as a dimension of American state identity, the impetus to further develop those weapons led to an increase in the number, scope and tempo of U.S. test series. Gone were the operational pauses seen under Truman, such as in 1947, 1949 and 1950, years during which no U.S. nuclear tests were conducted; rather, the United States conducted at least one test series, and sometimes two or three, each year between 1952 and 1958. Yet, unlike the acceleration of testing that followed Truman's decision in 1950 to pursue the hydrogen bomb, the acceleration under Eisenhower lacked a specific objective looming on the theoretical horizon. Rather, it was the further development of that weapon, including its miniaturisation and the diversification of its delivery platforms together with exploration of its effects, that propelled the U.S. nuclear testing program onwards. The competing requirements of these various objectives necessitated more and more tests. But the norm that this expansion rested upon – that nuclear testing was rational and acceptable state behaviour – was gradually eroded as the decade progressed. Despite parochial attempts by test advocates to populate that theoretical horizon with potential developments like the anti-missile missile and clean bomb, the expansion under Eisenhower was nonetheless arrested and testing voluntarily abandoned. I will now turn to the important elements of the process that led to the test moratorium, beginning with those most closely related to actual testing.

Tests, Test Detection, Technical Matters

At the same time that nuclear testing drove ahead understanding of weapons effects, so too did these tests contribute information relevant to the monitoring of any cessation agreement and a fuller appreciation of the difficulties of test detection. This appreciation was firstly an American one but was later shared with the Soviets through the forum of negotiations in Geneva; and the technical information provided by U.S. underground nuclear tests in 1957 and 1958 greatly complicated the negotiations for a cessation agreement between Washington and Moscow. These technical matters also became important discursive themes within the Eisenhower Administration as it grappled during its second term with the nuances of the test ban, the moratorium, and the monitoring of Soviet nuclear tests. No analysis of the path to the test moratorium can be complete without an appreciation of the technical matters that arose and ultimately spoiled efforts toward a test ban agreement during Eisenhower's presidency.

The two test series that contributed most to the issues of test detection and the monitoring of a cessation of testing were Operation PLUMBOB, held between May and October in 1957, and Phase II of Operation HARDTACK, held in September and October in 1958.[20] These series included a number of underground nuclear shots that furnished much data regarding the detectability of nuclear weapons detonated underground. The first of these was PLUMBBOB RAINIER, which was fired at the Nevada Test Site (NTS) on 19 September 1957. RAINIER was intended to demonstrate a method of nuclear testing that did not release fallout, and its success had obvious consequences – as Divine notes, "if world opinion forced the United States to stop testing in the atmosphere, RAINIER showed how the AEC could still verify its nuclear advances."[21] But because RAINIER so successfully contained the radiation associated with the shot, it demonstrated that underground nuclear tests could only be detected using a seismograph. Moreover, only about 1% of the energy

[20] For more information on these series, see Chapter Three.
[21] Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960*: 158.

of the 1.7 kiloton detonation was translated into a seismic wave, which was recorded on seismographs "several hundred miles" from the shot as a magnitude 4.2 earthquake (using the contemporary Richter rather than the modern moment magnitude scale).[22] These same seismographic records could not easily distinguish the RAINIER event from a small earthquake that followed less than an hour after the detonation.[23] The data regarding detection of underground nuclear detonations provided by RAINIER had obvious and troubling implications for the monitoring of a test cessation agreement.[24] Analysis of this data by physicists Hans Bethe and Harold Brown concluded that

> Complete containment of a test explosion underground, though devised as a method for making testing easier by eliminating fallout, may also serve as the most effective method of concealing the existence of tests, and may make it very difficult to gather effective proof that such tests have been carried out in violation of a suspension agreement.[25]

[22] Appendix C: Concealment and Detection of Nuclear Tests Underground, Harold Brown and Hans A. Bethe, appended to Memorandum for the Special Assistant to the President for National Security Affairs from J.R. Killian, 28 March 1958; NSC Series, Briefing Notes Subseries, Box 2; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.
[23] Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960*: 158.
[24] The "inconclusive" results of PLUMBBOB RAINIER were further complicated by misinformation publicised by the AEC many months later. The AEC reported in March 1958 that the seismic signals of RAINIER "had not been detected by seismic stations more than 250 miles [402 kilometres] from the Nevada test site." However, the Coast and Geodetic Survey confirmed that a station in Alaska had detected RAINIER at a distance of 2,300 miles [3,701 kilometres]. Senator Hubert Humphrey (D-MN) accused the AEC of deliberately distorting evidence for political reasons. The AEC apologized for an "inadvertent" and "bureaucratic" mistake. Ibid., 188.
[25] Appendix C: Concealment and Detection of Nuclear Tests Underground, Harold Brown and Hans A. Bethe, appended to Memorandum for the Special Assistant to the President for National Security Affairs from J.R. Killian, 28 March 1958; NSC Series, Briefing Notes Subseries, Box 2; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library. Harold Brown would later serve as Secretary of Defense in the administration of Jimmy Carter.

From the results of RAINIER, the United States concluded that a threshold existed at around magnitude 4.5 on the Richter scale above which underground nuclear detonations could be detected using seismographic methods. RAINIER had yielded 1.7 kilotons and produced a magnitude 4.2 signal; thus, tests that fell under this threshold and escaped detection would consequently be of a limited yield. It was with this threshold in mind that U.S. scientists began discussing inspection and detection with their Soviet counterparts in Geneva in July 1958. The Geneva Conference of Experts, which included scientists from the United States and the Soviet Union, met to discuss issues of test detection as they related to a possible suspension agreement, and it was through this forum that the U.S. communicated the results of RAINIER. Through "protracted and difficult negotiations" over July and August, the Conference of Experts recommended a detection system similar to that which had already been proposed to the NSC in April.[26] Assuming a threshold of magnitude 4.5, both systems "would have a good capability of detecting underground tests of about 5 kilotons" and "estimated that 90% of the earthquakes of equivalent magnitude could be identified as earthquakes and distinguished from explosions."[27] The effectiveness of such a system left between twenty and one hundred earthquakes per year with a magnitude equivalent to a 5 kiloton test unidentified.[28]

But the data that generated the threshold that was the basis of these detection systems was itself derived from a single test. Bethe and Brown noted in their analysis

[26] The system submitted to the NSC was from the Ad Hoc Working Group, which was established in January of 1958 to study "the military effects of a possible test cessation and of the feasibility of detecting atomic weapons tests." The Ad Hoc Working Group submitted its findings on 3 April, 1958. Considerations on Discontinuance of Atomic Weapons Tests; Office of the Special Assistant for Science and Technology (James R. Killian and George B. Kistiakowsky): Records, 1957-1961, Box 8; White House Office; Dwight D. Eisenhower Library.
[27] Ibid.
[28] Ibid.

of the implications of RAINIER for test concealment and detection that "experiments are urgently needed to establish the actual relation between yield and seismic signal."[29] This was because RAINIER was fired in volcanic tuff that "probably gives a relatively small seismic signal…equivalent to an air shot of about 20 times greater yield."[30] Other geological mediums could produce different seismic signals – hard rock, for example, would be more conductive while less dense, unconsolidated rocks would further attenuate the seismic signal – and an understanding of the effects of a nuclear detonation in these mediums was necessary. The underground shots of HARDTACK II responded to this need.

Twelve shots of Operation HARDTACK II were fired in tunnels or underground, and it were these that profoundly revised the data garnered from Operation PLUMBBOB.[31] The seismic signatures of the HARDTACK II underground tests were two-thirds the strength of those expected based on the data from PLUMBBOB RAINIER; moreover, the seismographic stations that detected RAINIER in the previous year were shown to be overly sensitive by the HARDTACK II tests. The overall effect was a general revising downward of the potential to detect underground nuclear tests such that "a given signal strength [required] about twice as

[29] Appendix C: Concealment and Detection of Nuclear Tests Underground, Harold Brown and Hans A. Bethe, appended to Memorandum for the Special Assistant to the President for National Security Affairs from J.R. Killian, 28 March 1958; NSC Series, Briefing Notes Subseries, Box 2; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.
[30] Ibid.
[31] Unlike the case of RAINIER, no single underground test of HARDTACK II generated information regarding seismic signals. However, a report to the assistant to the president for science and technology mentions, within the context of HARDTACK II, that "two explosions have greatly increased our knowledge of seismic signals produced by explosions." Unfortunately, that part of the document that would identify the two important tests remains redacted. Ibid.

much explosive yield as had been previously supposed."[32] The conclusions reached by the Panel of Experts were immediately superseded. The accuracy of detecting shots above 5 kilotons in yield dropped from 90% to about 40%, while to retain that accuracy of 90% the detection threshold had to be raised from 5 kilotons to 25 kilotons.[33] This drop in accuracy and the corresponding increase in the yield of underground tests that could entirely escape detection had obvious implications for a nation – presumed by Washington to be the Soviet Union – that conducted a clandestine, underground testing program in violation of a suspension or cessation agreement.[34]

Gordon Gray, the national security advisor, met with Edward Teller while HARDTACK II was underway and discussed just this possibility of violation.[35] In the course of their discussion travelling from Las Vegas to the NTS, Teller articulated a number of interesting points. Teller stated that he did not believe atmospheric shots were essential for the development of weapons, "but are important for weapons effects."[36] This statement was likely true, given the importance of airbursts for effects tests, although it was a statement that could be made only at the end of 1958 when the

[32] Ibid.
[33] Ibid. The number of unidentified earthquakes per year with an equivalent strength to a 5 kiloton test rose from between twenty and one hundred (using the RAINIER data) to 1500 (using the HARDTACK data).
[34] Eisenhower later questioned in his memoirs: "If such discoveries could bring about drastic changes in the structure of fact upon which we made our calculations, what new discoveries were in the offing?" Quoted in Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960*: 246.
[35] Gray became Eisenhower's national security advisor in 1958, before which he had served as the chairman of the committee that revoked Oppenheimer's security clearance in 1954.
[36] Memorandum of Conversation with Dr. Edward teller, 9 October 1958; Special Assistant Series, Subject Subseries, Box 11; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.

major weapons development shots that had led first to the atom bomb, then to the boosted fission bomb, finally to the hydrogen bomb, and then to the diversification and miniaturisation of these weapons, had already been fired in the atmosphere. Teller went on to suggest that "a series of underground tests, under 1 KT, progressively pursued, could enable the development of weapons of increasing yield without too great risk of detection."[37] Here Teller was saying that a test program conducted by a violator within that low-yield bracket of events that could not be accurately identified as weapons test could lead to technical developments in weapons design – and this comment was made before the results of HARDTACK II effectively expanded that bracket to include shots up to 25 kilotons. Unsurprisingly, Teller concluded his discussion with Gray with the observation that a test moratorium was not in the interest of the United States, but remarked that if the moratorium was to go ahead then it should ban only those shots "that can be policed."[38]

Perhaps most concerning of Teller's statements during that discussion with Gordon Gray was related to a theory that would come to be known as decoupling. Noting that an underground test was likely "more difficult to detect…if it is fired in hard rock," Teller also commented that "it is believed that an appropriate structure around the device could, in effect, decouple the transmission of shock waves to the earth."[39] Decoupling involved the detonation of a nuclear device within a subterranean, hollow chamber that would absorb an amount of the shockwave and thus muffle the seismic signal that was transmitted into the surrounding earth. Because it remained a theory, scientists could not agree on the exact amount to which decoupling would reduce a seismic signal. For example, John McCone, the new

[37] Ibid.
[38] Ibid.
[39] Ibid.

chairman of the AEC following the departure of Lewis Strauss at the end of June 1958, stated in a meeting with the NSC that "concealing underground explosions through detonation in specially designed chambers or holes" would decouple the seismic signal "by a factor of 10 to several hundred times."[40] McCone then quoted Teller to the effect that a 1.7 kiloton device, detonated in a chamber 120 feet (36.5 metres) in diameter would produce "virtually no detectable signal" while a 200 kiloton device, detonated in a chamber 360 feet (109.7 metres) in diameter would produce a seismic signal equivalent to a 1 kiloton test.[41] James Killian, special assistant to Eisenhower for science and technology, immediately rejected these figures. Killian stated that decoupling remained a theoretical study and that the same study to which McCone referred had calculated much larger chamber sizes than those articulated by Teller. Nonetheless, the notion that an underground test could be more effectively hidden through decoupling only further undermined efforts toward, and muddied the debate regarding, a test cessation agreement.

If the opponents of the test moratorium can be accused, from the safety of the post-Cold War world, of one failing, it was that they often confused possibility with probability. On the issue of decoupling this failing was acute. Because decoupling was possible, opponents such as Teller and McCone saw decoupling as probable, and in the debate regarding the moratorium they made that probability seem more likely by understating the difficulties involved in decoupling (such as understating the size of decoupling chambers). Killian wrote a memorandum to Eisenhower over a month before the aforementioned NSC meeting in which he outlined a handful of technical

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[40] Memorandum of Conversation, U.S. Position in Geneva Nuclear Test Negotiations, 5 May 1959; McCone, John A., Papers, 1958-1961, Box 5; Dwight D. Eisenhower Library.
[41] Ibid.

factors relating to the test ban negotiations, and among these factors Killian discussed the inherent difficulties of decoupling. He noted that "by deliberate concealment" it would be possible to decouple the seismic signal of an underground nuclear test "by a factor of 10 or more" and possibly "by a factor much larger than this" – but nowhere did he mention the "several hundred times" that McCone submitted.[42] Certainly, the detection threshold of a system such as that outlined by the Panel of Experts "would be as high as several hundred kilotons" – but only if the violator "resorted to very expensive measures to try to achieve concealment."[43] This is a crucial point. The excavation and construction of the kind of underground chambers envisioned by decoupling would be expensive, possibly prohibitively expensive. Indeed, Killian wrote that "attempts to conceal tests, either underground or in outer space, would be very costly."[44] Killian derived at least some of this information from Bethe, who had only days before written to Killian that the excavation of a decoupling chamber would be "fairly costly" and that cost would increase if the decoupled shot was part of the kind of progressive test series Teller imagined because "its use might be limited to a

[42] Memorandum for the President on Some Technical Matters Involved in Policy Decisions on Arms Limitations and Specifically on the Limitation of Nuclear Testing, J.R. Killian, Jr., 31 March 1959; Administration Series, Box 23; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.
[43] Ibid.
[44] In a meeting two weeks later between representatives of the Departments of State and Defense and the AEC and CIA, deputy secretary of defense Donald A. Quarles admitted to McCone and Killian that "it would undoubtedly be more expensive to do all our testing in the underground and outer space environments." Memorandum of Conversation, Geneva Nuclear Test Negotiations, 15 April 1959; NSC Series, Briefing Note Subseries, Box 1; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library. Quarles would suddenly die of a heart attack less than a month later.

single occasion because it might cave in."[45] Bethe and Brown also highlighted the difficulties of scaling involved in decoupling higher yield tests – the reduction of seismic signals appeared easier for low-yield shots than for high-yield, because "the digging of underground caves large enough to give a substantial reduction of seismic signal from a 50-kiloton explosion will be very costly and *may in fact be impossible*."[46]

In addition to the problems of actually constructing underground chambers for decoupled tests, the act of excavation itself would potentially be observable even if the seismic signals themselves were not. Bethe suggested that roads or other "unusual human activity" would be indicators of test preparations in remote areas, while human intelligence would identify preparations in populated areas.[47] This suggestion may seem overly optimistic coming from a test ban advocate, but it touched on another important point. The spoil from excavation as well as the activity of excavation itself could be observable to high-altitude surveillance, and, although not assured, offered along with the extreme cost of construction a deterrent against decoupling. The CIA submitted a national intelligence estimate in 1961 that mentioned just this. Noting that

[45] Appendix C: Concealment and Detection of Nuclear Tests Underground, Harold Brown and Hans A. Bethe, appended to Memorandum for the Special Assistant to the President for National Security Affairs from J.R. Killian, 28 March 1958; NSC Series, Briefing Notes Subseries, Box 2; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.

[46] Ibid. Emphasis is my own. Killian and Bethe wrote their respective memoranda in the fortnight following the release of the Berkner Panel on seismic improvement, which confirmed the theory of decoupling but showed that very large caverns were required. See part three of chapter nine of Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960*: 251-55.

[47] Appendix C: Concealment and Detection of Nuclear Tests Underground, Harold Brown and Hans A. Bethe, appended to Memorandum for the Special Assistant to the President for National Security Affairs from J.R. Killian, 28 March 1958; NSC Series, Briefing Notes Subseries, Box 2; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.

the combination of decoupling within a hard medium (such as granite or salt) could achieve great reduction of seismic signal, the report crucially countered that "the scale of operations required for carrying out decoupling tests is such that other intelligence techniques would have an increased opportunity for detecting them."[48] Indeed, these "other intelligence techniques" were successful in detecting a Soviet high-explosive experiment in Kyrgyzstan in the winter of 1959-60 during which the Soviet Union apparently used conventional explosives "to study methods of clandestine nuclear testing."[49]

Eisenhower accepted these arguments by 1959. In a meeting in July that year, the president said that "the cost of concealment of large-size tests would appear to be exorbitant," and commented further "on the estimate that 15 million tons of earth must be moved in order to accomplish maximum reduction of the seismic signal of a 100 KT test shot."[50] Allen Dulles agreed to these comments and added that the Soviet Union would fear detection of the construction necessary for effective decoupled tests. That both the president and director of the CIA accepted these arguments in 1959 partly explains their commitment to an unverified test suspension agreement in 1958.

The matter of underground test detection and particularly of decoupling demonstrates the looping interrelationship between nuclear testing and any agreement that would suspend or cease testing. The results of the PLUMBBOB series in 1957

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[48] Special National Intelligence Estimate Number 11-9-61: The Possibility of Soviet Nuclear Testing During the Moratorium, 25 April 1961; Robert W. Komer, Reference Copy, Box 439; National Security Files; Papers of President Kennedy; John F. Kennedy Library.

[49] Ibid.

[50] Memorandum of Conference with the President, 23 July 1959; Subject Series, Alphabetical Subseries, Box 3; White House Office: Office of the Staff Secretary, 1952-1961; Dwight D. Eisenhower Library.

generated awareness of the problems regarding test detection, and this awareness in turn drove a need for further testing that was borne out in the HARDTACK II series in 1958 – and the results of HARDTACK II in turn impelled further testing. In the last half on 1959 – that is, a year after the test moratorium had begun – efforts were made within the Eisenhower Administration to conduct a fresh series of tests with the express intent to experiment with decoupling. In July, discussion between Gordon Gray and George Kistiakowsky (who had taken over as Eisenhower's science advisor after Killian) remarked that tests fired using decoupling could "be possible within about 18 months to two years" and that these tests would determine "how big" the decoupling chambers could be made and the "practical upper yield limit for this type of testing."[51] By December, the AEC had drafted an announcement of this series. Underground tunnels and shafts were constructed in granite outcroppings at the Nevada Test Site, and the AEC was looking further beyond the NTS and "surveying sites suitable for the construction of a large cavity for possible use for a nuclear experiment to investigate seismic decoupling."[52] This draft called for a 5 kiloton shot in a granite medium, two 5 kiloton shots "near the Rainier [sic] site but at appreciably greater depth," plus an additional shot of unknown yield "in an environmental

[51] Some Policy Considerations Based on Technical Data Concerning Nuclear Test Suspension, appended to Letter from Gordon Gray to Dr. Kistiakowsky, 3 August 1959; Office of the Special Assistant for Science and Technology (James R. Killian and George B. Kistiakowsky): Records, 1957-1961, Box 8; White House Office; Dwight D. Eisenhower Library. This document refers to decoupling chambers as "Latter Holes" after Albert Latter whose calculations had formed the basis of the Berkner Panel's understanding of decoupling.

[52] Proposed AEC Public Announcement, Letter from A.R. Leudecke to Bromley Smith, 7 December 1959; NSC Series, Briefing Notes Subseries, Box 2; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.

situation designed to decouple explosion energy from seismic energy."[53] In a cabinet meeting held on 11 December to discuss the ongoing Geneva negotiations, Eisenhower approved the test series but lamented that he "did not know how to handle the public relations aspect without serious propaganda danger during the presently announced moratorium period."[54] Eisenhower's approval came at a time when the officially announced moratorium of one year had expired on 31 October, but had been voluntarily extended through to 31 December. The president "felt that these experiments should go forward as quickly as possible after 1 January."[55] This series did not in fact go ahead – on 29 December Eisenhower announced the end of the moratorium but pledged that the United States would not resume nuclear testing without prior notice, and no U.S. nuclear tests were held until the NOUGAT series in 1961. Nonetheless, this test series that almost-was remains a final reminder of the feedback loop between testing and the issues of test detection, and this loop imparted momentum to continued testing, even during the moratorium.

While much of the focus of test detection was placed on underground testing, weapons tests conducted by the United States in 1958 had revealed another medium in which nuclear testing could escape detection: outer space. As part of Operation HARDTACK Phase I, three shots of Operation NEWSREEL had been fired at altitudes between 86,000 feet and 252,000 feet (26,212-76,809 metres) to determine, among other objectives, the United States' capability to detect high-altitude nuclear

[53] Ibid.
[54] Record of Cabinet Meeting, 11 December 1959, Consideration of Test Moratorium Negotiations; NSC Series, Briefing Notes Subseries, Box 2; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.
[55] Ibid. In this same cabinet meeting, secretary of state Christian Herter (made secretary shortly before John Foster Dulles's death earlier in 1959) remarked that "if decoupling worked much greater shots could be concealed but decoupling was expensive."

detonations.[56] NEWSREEL demonstrated that nuclear tests fired at altitudes between twenty and "a few hundred" miles were "easily detectable" largely because of the effect they had upon the Earth's ionosphere.[57] However, tests fired beyond this altitude (that is, in outer space) could escape detection. This realisation began what in hindsight seems a bizarre speculation on the extent to which the United States or the Soviet Union might go to violate a test cessation agreement. Using rockets to launch nuclear devices beyond orbit of Earth, it was speculated that tests could be conducted behind the Moon, in orbit of Mars, or even behind the Sun. Such tests would take "about a year" to reach their destinations and as a result "tests cannot be conducted in quick succession."[58] The U.S. delegation to the Geneva Conference proposed a system of satellites that would detect the x-rays generated by outer space tests, and anticipated that such a system could detect a one megaton test at a distance of one billion miles (1,609,344,000 kilometres).[59] Yet, as with decoupling in the case of underground tests, outer space tests could be further hidden by conducting them behind a planet or by hiding the emission behind "suitable shields":

> One can think of very large rockets (millions of pounds of thrust, as are now under development by NASA) lifting a nuclear weapon inside a very heavy and elaborate shield to altitudes of hundreds or thousands of miles. All long-

[56] Letter from Lewis Strauss to President Eisenhower, 2 August 1957; Administration Series, Box 5; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library. For more information on HARDTACK I and NEWSREEL, see Chapter Three.

[57] Considerations on Discontinuance of Atomic Weapons Tests; Office of the Special Assistant for Science and Technology (James R. Killian and George B. Kistiakowsky): Records, 1957-1961, Box 8; White House Office; Dwight D. Eisenhower Library.

[58] Ibid.

[59] This figure is farther than the distance between the Sun and Saturn, and is roughly ten times the distance from the Sun to Earth.

> range [that is, detectable] effects of the weapons will subside before the shield is destroyed.[60]

The notion that clandestine nuclear testing could be conducted through the solar system seems a peculiar one but it is important to remember that it dates from the dawn of the space age. The superpowers had developed only embryonic space programs in 1959 but already nuclear weapons tests had moved into the high atmosphere and beyond. Moreover, the Soviet Union with Sputnik had visibly established its lead in the space race only two years earlier. The same distrust that was shown in the field of underground test detection was naturally transferred to the field of outer space, a field in which the Soviet Union, at least at the end of the 1950s, was technically ahead of the United States. But most important, for the purposes of test detection, speculation on outer space testing, outlandish as it was, illustrated not only the immense technical difficulties associated with a test cessation agreement but that these difficulties had to be fully explored and understood in order to have confidence in such an agreement.

While initially intended to experiment in mediums that would reduce or eliminate fallout, the underground nuclear weapons tests of PLUMBBOB in 1957 and HARDTACK II in 1958 – and, to a lesser extent, the high altitude tests of HARDTACK I in 1958 – also demonstrated the increasing difficulty of detecting nuclear tests that a determined power could conduct clandestinely. These difficulties were explored, debated, and at times politicised in the months leading up to the test moratorium that began on 31 October 1958, and they continued to pose problems

[60] Ibid and Some Policy Considerations Based on Technical Data Concerning Nuclear Test Suspension, appended to Letter from Gordon Gray to Dr. Kistiakowsky, 3 August 1959; Office of the Special Assistant for Science and Technology (James R. Killian and George B. Kistiakowsky): Records, 1957-1961, Box 8; White House Office; Dwight D. Eisenhower Library.

through 1959. At the core of these technical matters of detection was a conflict between possibility and probability, and figures within the Eisenhower Administration on both side of the test ban debate portrayed their arguments in terms of that tension between possibility and probability. The need to objectively determine the probability of evading detection created a feedback loop that encouraged more and further nuclear testing, a loop not dissimilar to that which in the first half of the 1950s had greatly expanded U.S. nuclear testing to accommodate weapons effects studies. The methods of conducting clandestine tests that avoided detection were difficult and expensive and, at least in the case of decoupling, could potentially be detectable even if the test itself was not. But so long as these methods remained possible a test cessation agreement would be imperfect, and it was with these technical matters at the forefront of debate that the Eisenhower Administration committed to the test moratorium.

Moratorium

The moratorium on nuclear testing began on 31 October 1958 and remained in effect until after Eisenhower had left office. It was a voluntary suspension agreement that stood in place of a wider, more effective and, importantly, adequately monitored cessation agreement that was to be negotiated in Geneva concurrent to the moratorium. This cessation agreement did not eventuate, leaving an imperfect moratorium that could be (and eventually was) violated. Nonetheless, the moratorium was crucial for stemming the spiralling expansion of nuclear testing during Eisenhower's presidency. Furthermore, debate within the administration regarding the moratorium is useful for exploring the rational purposes of nuclear testing. This debate provides an apt demonstration of Sagan's parochial model in the context of U.S. nuclear testing.

Divine in 1978 speculated that Eisenhower as early as 1954 showed an interest in test suspension. Greene gives Divine deserved recognition for the accuracy of his speculation.[61] The early discussion of an agreement to limit nuclear testing dates from before the CASTLE BRAVO shot of March 1954. Chapter Three mentioned the efforts of Vannevar Bush – the scientist and engineer who advised President Roosevelt on scientific matters and who helped administer the Manhattan Project – to prevent the first test of the hydrogen bomb in 1952 and so develop an agreement with the Soviet Union preventing their full development. By early 1954, efforts to limit large-scale nuclear tests such as test of hydrogen bombs had been taken up by Thomas E. Murray, one of the commissioners of the AEC.[62] Writing to Eisenhower in February 1954, Murray suggested "an attempt to negotiate an agreement to limit testing activities" as "a possible step leading to international control of atomic weapons."[63] Murray noted that the development of high yield weapons required "full-scale" testing, and that "by their nature such tests cannot be kept secret"; for just this reason, Murray supposed, any agreement to limit high yield testing would be "self-policing."[64] In addition to the lessening of world tensions, Murray identified a more

[61] Greene, *Eisenhower, Science Advice, and the Nuclear Test Ban Debate, 1945-1963*: 2.
[62] Murray, in the vein of both Brien McMahon and Lewis Strauss, was a millionaire in his own right. Tannenwald describes his "strong Catholic beliefs" that made him "the conscience of the AEC." Murray had a close relationship with Truman but an adversarial one with Strauss; by 1957, when Murray was reappointed to the AEC, he was the only Democratic member. Tannenwald, *The Nuclear Taboo*, 100.
[63] Letter to President Eisenhower from Thomas E. Murray, 5 February 1954; Administration Series, Box 4; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.
[64] Ibid.

compelling and tangible reason for such an agreement. While the development of high yield weapons relied upon full-scale tests, a moratorium on testing "might prevent the future development of the much larger yield weapons about which scientists were now theorizing."[65] But Murray was writing at an awkward time for the administration to consider test suspension, and Murray knew it. He concluded his letter to the president acknowledging that it was "untimely" to present his plan "on the eve of our next Pacific tests."[66] Indeed, CASTLE BRAVO was detonated less than a month after Murray's letter, and its radiological effects and the controversy they generated did much more for the cause of a test ban agreement than Murray's letter of February.

Admiral Arthur W. Radford, the chairman of the JCS, submitted the views of that body regarding a test moratorium to the NSC at the end of April, and this memorandum articulates the early opposition of the Department of Defense to a test suspension agreement. At the core of the JCS opposition was the notion that, in 1954, the United States had an "indeterminate advantage" over the Soviet Union in the development and production of thermonuclear weapons, and that although a moratorium could potentially freeze this lead, it would not prevent the Soviet Union from continued theoretical developments that could then be proven through nuclear tests if Moscow chose to abrogate an agreement.[67] This fear was partly realised in 1961. Radford noted that the advantage that the United States held in 1954 would "readily be neutralized" in such a circumstance and, as a result, the political

[65] Ibid.
[66] Ibid.
[67] Memorandum for the Secretary of Defense from Admiral Arthur Radford, 30 April 1954; NSC Series, Briefing Notes Subseries, Box 1; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.

advantages of a test suspension agreement were "transitory in nature" while the military disadvantages would be "far-reaching and permanent."[68]

Serious discussion within the administration of a test ban proposal began in the months after BRAVO. Meetings of the NSC at the end of May and again at the end of June discussed such a proposal in surprisingly detailed terms – and this at a time when the Army-McCarthy hearings had begun only months prior but before the furore over BRAVO reached a crescendo with the death of Aikichi Kuboyama, the radioman of the Japanese fishing boat *Lucky Dragon*.[69] A committee of the State Department had studied the issue of a test ban "intensively" in the fortnight before the May meeting and proposed a suspension of tests above 100 kilotons, a threshold below which tests in the Soviet Union were difficult to detect and below which the United States could still make important technological and theoretical developments in the field of nuclear weapons. The meeting of May saw John Foster Dulles, the secretary of state, express concern that the "propaganda ball" could be taken from Washington by Moscow if a test ban was proposed and the Soviet Union responded by proposing a lower threshold, perhaps fifty kilotons.[70] This was probably the beginning of Dulles's wavering support for a suspension agreement.[71] Although the matter was deferred until the next meeting of the NSC, several particularly prescient comments were made at the May meeting. The president asked about the "largest size

[68] Ibid.

[69] For more on the death of Aikichi Kuboyama, see Chapter Three. For the context of public reaction to CASTLE BRAVO, see chapter one of Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960*: 3-35.

[70] Discussion at the 199th Meeting of the National Security Council, Thursday, May 27, 1954; NSC Series, Box 5; Eisenhower, Dwight D.: Papers as President, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

[71] For a good account of the secretary of state's shifting support for a suspension agreement, see chapters three and four of Greene, *Eisenhower, Science Advice, and the Nuclear Test Ban Debate, 1945-1963*: 51-86.

weapon" the Soviets could test without being detected by the United States. Strauss replied that "we would know of any explosion which yielded more than 10 KT equivalent, *unless the Soviets took the most extraordinary precautions to prevent us learning about a test*."[72] Such precautions may have included those mentioned above, including decoupling and outer space testing, which would not be fully understood until at least four years after Strauss made this statement. Eisenhower reacted to Strauss's comment with some poignant solemnity – "it was…a matter of despair to look ahead to a future which contained nothing but more and more bombs" – that spoke to his deeper desire to limit nuclear testing.[73]

The NSC returned to the topic of a moratorium proposal in June and further details were discussed. In addition to the threshold of 100 kilotons, it was now proposed that a moratorium last only until January 1956, that is, for eighteen months. A moratorium lasting this long "would be advantageous to the United States from a technical point of view" but would be disadvantageous "if it was to last any longer."[74] Strauss explained to the president why it was important to recommence testing in 1956. The AEC and the JCS required a "small megaton weapon for defense against hostile aircraft" and work was still underway on just such a device, which would not be ready to test until 1956. The JCS believed that testing such a weapon and adding it

[72] Discussion at the 199th Meeting of the National Security Council, Thursday, May 27, 1954; NSC Series, Box 5; Eisenhower, Dwight D.: Papers as President, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library. Emphasis is my own.
[73] Eisenhower also said that, once a suspension agreement took effect, "the minute we learned that the Soviets had not stopped testing these weapons, we would ourselves start our own tests again." Ibid. His resolve was tested at the beginning of November 1958, which I discuss later in this chapter.
[74] Discussion at the 203rd Meeting of the National Security Council, Wednesday, June 23, 1954; NSC Series, Box 5; Eisenhower, Dwight D.: Papers as President, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

to the U.S. nuclear arsenal was "indispensable."[75] Here Strauss had identified at least one potential use of nuclear testing that was more important than a suspension agreement, which, as was entirely characteristic of Strauss, missed completely the point of a suspension agreement as it was imagined by Bush, Murray, and later Adlai Stevenson and Eisenhower himself. Similarly, the combined proposals of an exemption of tests below 100 kilotons with the set expiry date of January 1956 was a position that had been tailored to Washington's advantage, a fact that the Soviet Union "would quickly grasp."[76] The Soviet Union had by June 1954 conducted seven tests in three series (compared to the United States' forty-seven tests in ten series) and Moscow would need to conduct high-yield tests in the future in order to produce and stockpile multi-megaton weapons.[77] A test moratorium such as that contemplated by the NSC would freeze the United States with a substantial lead over the Soviet Union. At this point, in the middle of 1954, it seems that the NSC saw a test moratorium as a strategy to consolidate the United States' lead in nuclear weaponry, while also scoring a propaganda victory, and it was not yet seen as a serious step toward halting the arms race. Indeed, in this June meeting, the sobriety with which Eisenhower had concluded the May meeting was entirely absent. The president spoke in terms of the relative power balance between the United States and the Soviet Union, and was confident that there was "no way in which the United States could be licked by any enemy in a

[75] Ibid.
[76] Ibid.
[77] Memorandum for the Executive Secretary, National Security Council, Subject: Department of State Views on the Proposed Moratorium on Tests, 23 June 1954; NSC Series, Briefing Note Subseries, Box 1; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library. This memorandum concluded that it would be a "mistake" for the U.S. to enter such a moratorium partly because "the proposal implies…that there is something morally wrong in explosions in excess of a certain power."

protracted war of exhaustion unless we were the victims of surprise atomic attack."[78] The president concluded this meeting of the NSC by saying that "in any event we were not going to stop conducting tests of atomic weapons, and that there was no reason to do so until some new alternative was in sight."[79] Such an alternative would not realistically emerge until two years later during the presidential election of 1956.

Limited and flawed as these early efforts toward a suspension agreement were, it is important to question why they were unsuccessful and why history remembers the nuclear test moratorium commencing in 1958 and not 1954. Greene attributes much of the blame for its failure on Lewis Strauss, whose mastery of bureaucracy and command of Eisenhower's ear far exceeded proponents like Murray and even Eisenhower's chief of disarmament, Harold Stassen. That mastery would not be eroded until 1957 when the crisis sparked by Sputnik led to a fundamental change in the way Eisenhower received advice on scientific and technical matters.[80] Certainly, the internal opposition within the administration was crucial to the failure in 1954 to seriously consider a suspension of nuclear tests. But Eisenhower faced a more vague, less determinate problem. Many years later, after the departure of Strauss and when the moratorium had begun, the president confided to his scientific advisors that

> beginning three or four years ago [that is, around 1955-56] he had the idea of stopping atmospheric tests. He encountered enormous resistance and found very little support initially. The lesson is that the great task is to bring thinking along, since in a democracy public opinion weighs so heavily.[81]

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[78] Discussion at the 203rd Meeting of the National Security Council, Wednesday, June 23, 1954; NSC Series, Box 5; Eisenhower, Dwight D.: Papers as President, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.
[79] Ibid.
[80] Greene devotes an entire chapter of his work to the influence Strauss exerted in these matters. See chapter six of Greene, *Eisenhower, Science Advice, and the Nuclear Test Ban Debate, 1945-1963*: 112-33.
[81] Memorandum of Conference with the President, May 19, 1959, 11 AM; DDE Diary Series, Box 41; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

Greene argues that the 1954 consideration of a test ban failed because Strauss "deftly controlled scientific conclusions" regarding the ban and because Eisenhower would not overrule the arguments of his advisors.[82] This is certainly true. However, while the debate in 1954 was not of the magnitude as some years later, it was nonetheless important because it began the "great task" of "bringing thinking along" to the point where, in 1958, the United States voluntarily suspended testing.[83] That this task began relatively early in Eisenhower's tenure should not be understated, because it allowed test ban proponents to continue this process in the remaining years of the administration. The fallout, both radiological and in the public debate, from CASTLE BRAVO accelerated this process, as did the election campaign of the Democratic nominee for the 1956 presidential election, Adlai Stevenson.

The 1956 election was a re-match of that which in 1952 had brought Eisenhower to office, and it resulted in the re-election of Eisenhower by an even greater percentage of both the electoral college and popular vote than 1952. The 1956 election is important for the understanding of U.S. nuclear testing, because Eisenhower's opponent, Adlai Stevenson, campaigned partly on the issue of a nuclear test ban. Both Divine and Greene explore the election campaign in great detail and this thesis contributes nothing new to its understanding.[84] It is sufficient to remark that Stevenson – at first with trepidation but then with growing confidence – transformed the test moratorium into a central election platform that in turn produced

[82] Greene, *Eisenhower, Science Advice, and the Nuclear Test Ban Debate, 1945-1963*: 85.
[83] For an excellent account of the evolution of public opinion regarding a test suspension agreement, see Rosi, "Mass and Attentive Opinion on Nuclear Weapons Tests and Fallout, 1954-1963."
[84] See chapter four of Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960*: 84-112; Greene, *Eisenhower, Science Advice, and the Nuclear Test Ban Debate, 1945-1963*: 87-111.

a vibrant and sometimes vitriolic public debate. Divine especially credits Stevenson's "eloquent advocacy" for bringing the test ban to the forefront of public discussion and achieving "a remarkable feat of public education."[85] Stevenson certainly transformed the test ban from the province of a particularly vocal but small minority to a core issue in a presidential election, and part of his success was in relating nuclear testing to the well-being of the American voter – specifically, in terms of radiation and fallout and public health. Although he lost the election, Adlai Stevenson gained substantial support on the issue of the test ban.[86]

Pedagogic though his campaigning on this issue was, Stevenson inevitably politicised an issue of great importance for the Eisenhower Administration and for the president personally. While Stevenson's discussion of a test ban remained tentative and uncommitted Eisenhower refrained from public comment, but privately expressed distaste that Stevenson had brought such an important issue into partisan politics; indeed, the aversion shown by Eisenhower was not dissimilar to that of Truman in 1952 when the IVY MIKE test was conducted during the week of the presidential election. The NSC had discussed a test suspension agreement since at least 1954, and by 1956 "the time seemed opportune," in the words of Divine, to pursue serious negotiations with the Soviet Union.[87] But Stevenson's advocacy of a test ban during the election campaign practically assured opposition from the Eisenhower Administration, such that by the end of the campaign Eisenhower was himself voicing arguments that smacked of Strauss and the JCS. At the end of October, Eisenhower

[85] Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960*: 112.
[86] Stevenson became the U.S. ambassador to the United Nations during the Kennedy Administration and in that capacity presented evidence of the installation of nuclear missiles in Cuba by the Soviet Union in October 1962. His famous "hell freezes over" speech was featured in the 2000 film *Thirteen Days*.
[87] Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960*: 111.

commented directly and at length on the issue of the test ban. He described the "critical issue" as not one of testing nuclear weapons but rather of preventing their use in war, stating that nuclear testing was a "lesser matter," and that the present rate of testing of thermonuclear weapons did not "imperil the health of humanity."[88] He further observed that testing had resulted both in cleaner weapons and weapons for the defense of the American people, and that the United States' "commanding lead" in the field of nuclear weaponry could be "erased or even reversed" if Washington agreed to a test ban.[89] Greene is intensely critical of the administration's response to Stevenson. He concludes that Eisenhower's victory in 1956 "resulted in a moratorium on his policy of candor [sic] to the American people on nuclear issues."[90] In hindsight, the Eisenhower Administration was probably unlikely to achieve a test moratorium in 1956 and so the positive effect of Stevenson's public discussion of a test ban was of greater consequence than the negative effect of its politicisation. Nonetheless, it is interesting and useful to consider the possibilities of a test moratorium negotiated with the Soviet Union before the 1957 PLUMBBOB and 1958 HARDTACK II test series complicated the issue of test detection.

Before the issue of test detection became acute with the results of the United States' underground tests, opposition to any test suspension or cessation agreement was framed in terms of its retarding effect on U.S. nuclear weapons development. The continued, progressive development of nuclear weapons was associated with the security of the United States. In April of 1956, before the emergence of the test ban as

[88] Statement by the President, 24 October 1956; Administration Series, Box 4; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.
[89] Ibid.
[90] Greene uses words like "secrecy," "deception," "manipulation and lying." Greene, *Eisenhower, Science Advice, and the Nuclear Test Ban Debate, 1945-1963*: 110-11.

an issue in the presidential election, the chief of staff of the U.S. Air Force (and later to be chairman of the JCS) General Nathan Twining wrote to Charles Wilson, the secretary of defense, arguing the need for multimegaton thermonuclear tests. Twining articulated two reasons for such tests: first, to better understand and control fallout and so develop cleaner weapons; and, second, to develop and improve nuclear air defense warheads.[91] Eisenhower mentioned both of these arguments in his statement of 24 October (cited above). The president returned to them in 1957 in a letter to Congressman Sterling Cole (R-NY):[92]

> There has been a great enhancement of our defensive strength through the developments which have come from the test program to date. We have increased the numbers, the deliverability, the efficiency and versatility of our weapons. Most recently, we have learned that certain of them can be made in such a manner that radioactive fall-out [sic] is very greatly minimized.[93]

It seems from his statements in 1956 and 1957 that the president repeated the arguments of those advisors opposed to a test ban when he conversed with sources outside the administration. This characteristic was probably a result of his reluctance to overrule his advisors on matters of the test ban, despite his own reservations, a reluctance that many other authors have noted.[94] Thus, these comments are likely not

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[91] Memorandum for the Secretary of Defense from N. F. Twining, 23 April 1956; Subject Series, Department of Defense Subseries, Box 4; Office of the Staff Secretary: Records of Paul T. Carroll, Andrew J. Goodpaster, L. Arthur Minnich, and Christopher H. Russell, 1952-1961; White House Office; Dwight D. Eisenhower Library.

[92] The correspondence between Eisenhower and Cole as it related to the upper yield of thermonuclear tests was explored in Chapter Three of this thesis.

[93] Letter to the Honorable Sterling Cole from President Eisenhower, 27 May 1957; DDE Diary Series, Box 24; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 [Ann Whitman File]; Dwight D. Eisenhower Library. This letter included the almost-farcical comment that Lewis Strauss "knowing my [Eisenhower's] views and sharing them fully…has held testing to an absolute minimum."

[94] Both Greene and Divine comment on Eisenhower's reliance upon his advisors until late 1957. Campbell Craig provides insight on Eisenhower's leadership style from a

entirely indicative of the president's own opinions but do show the reliance upon technical development that opponents used as a counter to the test ban proposal.

While technical arguments remained, the issue of radiation emerged in the aftermath of the 1956 campaign. In 1957 the Joint Committee on Atomic Energy (JCAE) convened a Special Subcommittee on Radiation, before which Willard Libby, a commissioner in the AEC, testified in June. Libby remarked that the United States required new weapons and that these new weapons "must be tested if we are to rely upon them in an emergency"; moreover, there was no substitute for testing to determine reliability for either a conventional or nuclear weapon.[95] To Libby, test suspension or cessation meant "cutting off attempts to achieve further improved designs – designs which could lessen still further radioactive contamination from detonations."[96] The design of a clean nuclear weapon – a theoretical device that produced less or no radioactive fallout[97] – was championed by opponents of the test ban. Edward Teller made the case for clean weapons in the 10 February 1958 edition of *Life* magazine, and this was followed by a memorandum to Eisenhower from the AEC which further detailed Teller's arguments. Beginning with the now-standard refrain that the dangers of testing nuclear weapons were eclipsed by the dangers of

different perspective, one more closely aligned to military doctrine. Campbell Craig, *Destroying the Village: Eisenhower and Thermonuclear War* (New York: Columbia University Press, 1998).

[95] Supplement to the Statement by Dr. Willard F. Libby Before the Special Subcommittee on Radiation, 5 June 1957; Administration Series, Box 5; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

[96] Ibid.

[97] The reduction of fallout was, theoretically, to be achieved through an entirely fusion reaction. However, fusion reactions in thermonuclear bombs were initiated by a fission bomb and it was the fissile material in the fission primary that created fallout. The fundamental requirement for this fission reaction to create the conditions for thermonuclear fusion presented an insuperable problem for the design of a clean bomb.

their use in war, this memorandum informed the president that the United States' clean weapons capabilities were "embryonic" and that there were no clean weapons in the nation's nuclear stockpile as of early 1958.[98] Compelling reasons for clean weapons were manifold. Foremost was to diminish the indiscriminate nature of nuclear weapons so that they more closely approached conventional weapons "in characteristics and reputation" and consequently have wider applications in both war and peace.[99] Such applications obviously appealed to American ideas of morality and self-interest.

But some of these military applications as they related to a clean weapon were dubious and spoke to the greater problem of the military need for clean weapons. For example, it was observed that hardened targets such as missile silos or underground bunkers required high-yield, surface-burst weapons to ensure their destruction, presumably because airburst detonations did not create the required blast overpressure. The memorandum of February 1958 suggested that clean weapons could fulfil this requirement with reduced fallout, but testing had shown that the interaction between the surface and the nuclear fireball produced large quantities of fallout, and this interaction remained the same if a clean weapon were detonated on the surface. This was a fact of which the AEC was aware and which Strauss himself had publicised in 1955.[100] Similarly, clean weapons were expected to be heavier and

[98] The Case for Clean Nuclear Weapons, attached to Memorandum to the President from F. M. Dearborn, Jr., 14 February 1958; Administration Series, Box 11; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.
[99] Ibid.
[100] In February 1955, Strauss stated publicly that fallout was a function of the nuclear fireball touching the surface of the earth and drawing up large amounts of material into the bomb cloud, which fell back to the ground as radioactive particles. Statement by Lewis Strauss, Chairman, United States Atomic Energy Commission, 15 February

less efficient in the use of nuclear material than "present" weapons, which lessened their appeal to the military because of the unfavourable relationship between weight, deliverability and effect.[101] Behind the promising façade of the clean weapon was a less-favourable reality: a theoretical concept that could not be realistically achieved and the military did not favour even if the fundamental problems were solved.

The twin, connected arguments of continued technical development of nuclear weapons and the need for a clean bomb were used by the JCS and Department of Defense in March 1958. General Maxwell Taylor wrote to the secretary of defense and articulated the opinions of the JCS on test cessation and these were in turn relayed to the Ad Hoc Panel on Nuclear Test Cessation.[102] Taylor wrote that because of the United States' imposing lead in numbers of nuclear weapons and production of fissile material, a moratorium against testing would allow the U.S. to "hold this position until about 1964."[103] The emphasis of this statement was on the size of the U.S. stockpile. A cessation of nuclear testing after the HARDTACK test series of that year would result, "at the very least, in a technological parity in nuclear weapons development between the two countries."[104] Gone was the notion that the United States could freeze its technological and theoretical advantage through a test moratorium that was seen in the discussions of 1954; rather, the U.S. possessed a

1955; Subject Series, Alphabetical Subseries, Box 3; White House Office: Office of the Staff Secretary, 1952-1961; Dwight D. Eisenhower Library.

[101] Annex I to Ibid.

[102] General Taylor was at this time chief of staff of the U.S. Army but would retire from service in 1959 because of his opposition to Eisenhower's defense policies. He returned to service under Kennedy first in an awkward position between the JCS and the president and eventually as chairman of the Joint Chiefs.

[103] Memorandum for the Secretary of Defense from General Maxwell D. Taylor, 13 March 1958; NSC Series, Subject Subseries, Box 6; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.

[104] Ibid.

much larger stockpile that expanding Soviet production would only equalize in 1964. Taylor remarked that continued improvements in yield-to-weight ratios, second-generation intercontinental and intermediate range ballistic missiles, and anti-missile missiles were only possible through testing – and recommended that "under no circumstances" should the United States discuss test cessation with the Soviet Union until the completion of the "key shots" of HARDTACK.[105] To Taylor's list deputy secretary of defense Donald Quarles appended the development of clean weapons, and commented upon the emerging concern that the Soviet Union might conduct clandestine nuclear test series.[106]

Interestingly, James Killian agreed with the JCS on at least one important point during a meeting with the president less than a month later. Killian presented the report of the Science Advisory Committee on the cessation of nuclear testing which concluded that a moratorium would "leave the United States in a position of technical advantage for a few years, which will otherwise be lost."[107] It is unclear whether Killian was referring to a technological advantage or to the kind of numerical advantage to which General Taylor referred. Nonetheless, the Science Advisory Committee concurred that the United States should cease testing only after the completion of HARDTACK.[108] The meeting concluded with Killian outlining the opposing sides in the parochial test ban debate: the science advisor and his committee

[105] Ibid.
[106] Memorandum for the Chairman, Ad Hoc Panel on Nuclear Test Cessation from Donald A. Quarles, 21 March 1958; NSC Series, Subject Subseries, Box 6; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.
[107] Memorandum of Conference with the President, 17 April 1958; DDE Diary Series, Box 32; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.
[108] Ibid.

favoured a moratorium, while those in the AEC and Department of Defense disagreed.

This division crystallised throughout 1958. In May both sides further enunciated their arguments to the president. Advocates of the test ban attacked the darling of the AEC, JCS and Department of Defense: the anti-intercontinental ballistic missile (AICBM) or anti-missile missile. The basic problems of the AICBM, the Science Advisory Committee argued, were non-nuclear in nature and could not be solved through further nuclear tests. These problems were technical and involved the electronic and guidance systems of the AICBM, and the warheads expected to be available after the completion of HARDTACK were to be adequate once “very difficult” technical problems with the delivery system were solved.[109] Moreover, the United States was far ahead of the Soviet Union in the field of the AICBM largely because Soviet “warhead capabilities” – presumably Moscow’s emphasis on heavy lift rocketry rather than light and accurate missiles – placed “very serious limitations” on a Soviet anti-missile missile.[110] (The Department of Defense would eventually concede that the fundamental problems of the AICBM were “engineering rather than nuclear” but not until a year later.)[111] Meanwhile the JCS repeated its position that a test ban would threaten weapons development programs – including tactical

[109] Summary of Test Cessation Information, 6 May 1958; Office of the Special Assistant for Science and Technology (James R. Killian and George B. Kistiakowsky): Records, 1957-1961, Box 8; White House Office; Dwight D. Eisenhower Library. Killian had also voiced this opinion in his meeting with Eisenhower in April.
[110] Ibid.
[111] During an interdepartmental meeting on the Geneva negotiations in April 1959, both Killian and Quarles agreed on this point. Memorandum of Conversation, Geneva Nuclear Negotiations, 15 April 1959; NSC Series, Briefing Notes Subseries, Box 1; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.

warheads, warheads for an AICBM, and clean weapons – but added that "[e]ven if the HARDTACK tests are a complete success, there will be a continued need for additional testing."[112] This was a very different tone to that sounded by Taylor just weeks before.

The repetition *ad nauseum* of the position of the JCS became a feature of the test moratorium. The JCS, appealing through the secretary of defense, wrote to Eisenhower no less than five times between March 1958 and August 1959 to express their opposition to the moratorium.[113] In addition to the letters of 13 March and 30 April, the chairman of the JCS wrote to the secretary of defense again on 15 August 1958,[114] and at least another two more times in August 1959 to appeal the extension of the moratorium.[115] Very little in these letters diverged from the arguments already outlined by the JCS in early 1958. General Twining consistently requested further testing, stating unequivocally that "the results at HARDTACK demonstrate the absolute necessity of testing weapons" for both developmental and proof-testing

[112] Memorandum for the Secretary of Defense from General N. F. Twining, 30 April 1958; Administration Series, Box 25; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.
[113] This figure relates only to those letters found in the archives of the Dwight D. Eisenhower Presidential Library and others may exist in archives that this author did not access.
[114] Memorandum for the Secretary of Defense from General N. F. Twining, 15 August 1958; DDE Diary Series, Box 35; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.
[115] Memorandum for the Secretary of Defense from General N. F. Twining, 14 August 1959; Administration Series, Box 25; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library; Memorandum for the Secretary of Defense from General N. F. Twining, 21 August 1959; NSC Series, Briefing Notes Subseries, Box 2; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.

reasons.[116] Twining feared the "stagnation" of the U.S. nuclear arsenal that was the "inevitable result" of a future without nuclear testing.[117] Many of the statements made by Twining in his 1959 letters are verbatim copies of the statements from his 1958 letters, and it is a powerful image, indeed, to see the chairman of the JCS repeating – Twining used words like "reaffirm" and "re-emphasize" – himself in multiple letters sent over an eighteen-month period. One can imagine Twining's frustration at the shift within the administration against the AEC and Department of Defense – a frustration that advocates of a test ban must also have felt in the early years of the Eisenhower Administration. Such was the scale of that shift that in forwarding the last of these appeals by Twining, Neil McElroy, the new secretary of defense, commented that for reasons "of world opinion and public concern over the hazards of atmospheric testing, I cannot support a position in favour of the resumption of relatively unlimited testing."[118]

At the end of March 1958 the Soviet Union concluded a series of thermonuclear tests and almost immediately declared a unilateral test suspension. Although Moscow was being disingenuous – Khrushchev had waited until the Soviet series was complete but before HARDTACK began, and the Soviet suspension coincided with the natural pause between test series – the Soviet suspension did place an onus upon the United States to respond. Killian presented the conclusions of the Science Advisory Committee to the president two weeks later, which, as noted above, recommended the cessation of U.S. nuclear tests. On 28 April the United States

[116] Memorandum for the Secretary of Defense from General N. F. Twining, 15 August 1958; DDE Diary Series, Box 35; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.
[117] Ibid.
[118] Letter to President Eisenhower from Neil H. McElroy, 14 September 1959; Administration Series, Box 25; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

commenced Operation HARDTACK Phase I. Finally, at the end of June, Lewis Strauss resigned from his chairmanship of the AEC, partly because his influence over Eisenhower had been almost entirely eroded by the reorganisation of presidential science advice following the Sputnik scare, but partly also due to the enemies that Strauss had accumulated in Washington (including at least one member of the JCAE) through his earlier, successful effort to strip Oppenheimer of his security clearance. Following these events, debate within the Eisenhower Administration regarding the moratorium intensified, particularly in the lead-up to the conclusion of the Conference of Experts in Geneva on 21 August and the announcement of the moratorium itself on 22 August.

The five days leading up to Eisenhower's announcement of a one-year moratorium on nuclear testing were filled with revealing discussion on the details of that moratorium. The bulk of the NSC met on 18 August to draft the president's statement for the moratorium, which the president stressed would be proposed only if technical agreement was reached at Geneva. Even at this late stage there was disagreement on the merits of a test moratorium: Killian believed the U.S. would be at a technical advantage relative to the Soviet Union through test cessation while McCone and Quarles regarded cessation as a military disadvantage.[119] The disagreement of the AEC, JCS and Department of Defense was obvious (the JCS were not represented at this conference). McCone said that the AEC "unanimously opposes the cessation of tests," but in a marked change from his behaviour with Strauss in years past Eisenhower "said he recognized that fact" but dismissed it

[119] Memorandum of Conference with the President, 18 August 1958; DDE Diary Series, Box 35; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

because the AEC was not concerned with world political opinion.[120] Two features of the moratorium were enunciated in this meeting: first, that tests would resume "on some certain date" in the absence of negotiated, adequate test controls; and, second, that no exception would be allowed for underground tests during a moratorium because "half of the impact would be lost."[121] Here again Eisenhower overruled McCone and Quarles, who argued in favour of continued underground tests during the moratorium.[122]

With the single-mindedness of his predecessor, McCone pursued underground testing the next day. On the morning of 19 August he saw Gordon Gray to say that he was "deeply disturbed about the President's decision not to go along with fully contained underground testing during the one-year unilateral suspension."[123] Both McCone and Gray went before Eisenhower that afternoon to discuss the chairman's "severe misgivings."[124] The president was sympathetic, particularly to the argument – which seemed to bear the hallmark of Teller – for peaceful nuclear tests, but ultimately directed McCone to the Department of State. Eisenhower met the next morning, 20 August, with Killian and Christian Herter, the acting secretary of state, and discussed elements of McCone's plea from the day before. The president said that the issue of peaceful tests carried out during the moratorium was "causing a great deal of difficulty within our own government" and that he thought it "a reasonable

[120] Ibid.
[121] Ibid.
[122] Memorandum of Meeting with the President, 18 August 1958 at 2:30p.m. on Draft Presidential Statement at time of release of report of Geneva Meeting on Nuclear Tests; Special Assistant Series, Presidential Subseries, Box 3; Office of the Special Assistant for National Security Affairs: Records, 1952-1961; White House Office; Dwight D. Eisenhower Library.
[123] Gray appended his account of the events of 19 August to his report on the previous day's meeting. Ibid.
[124] Ibid.

solution" to allow such tests during the moratorium.[125] Herter disagreed, citing scientific objections and the fear that the Soviet Union might misuse such peaceful tests to effectively cheat on the moratorium. Rather, he suggested that the moratorium be reduced to nine months rather than twelve, although this risked the appearance that Washington was discontinuing tests only until its next series was ready in the middle of 1959. This was of course exactly what the Soviet Union had done at the end of March. Remarkably, Eisenhower apparently continued to hedge toward the AEC even at this late juncture, and very important dimensions of the test moratorium had not yet been firmly decided two days before it was announced.

The president and the secretary of state met with the foreign minister and ambassador of France on 21 August, the day that the Panel of Experts in Geneva submitted its conclusions. In this meeting, foreign minister Couve de Murville "reminded" Eisenhower that

> the French Government does not agree with the action contemplated in the statement [the suspension of nuclear tests], in that it is not prepared to announce the same kind of undertaking on its part…[because] the United States has done all that it really needs to do in this field, but the French must carry out testing in order to produce weapons in the future.[126]

That the United States could carry the United Kingdom but not France with it into voluntary moratorium is unsurprising given the Gaullist impulse to develop nuclear weapons, the importance of testing to that development, and France's modest progress in the field relative to the U.S. and U.K. But there is a more important point found in de Murville's words: suspension of testing could only realistically be

[125] Memorandum of Conference with the President, August 20, 1958 – 11.15; DDE Diary Series, Box 35; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.
[126] Memorandum of Conversation, 21 August 1958; DDE Diary Series, Box 35; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library. Indeed, France would be the only nation to conduct a nuclear test between 3 November 1958 and 1 September 1961.

contemplated by a nuclear power that had already tested extensively and developed weapons as a result of those tests. This was a notion hinted at by test ban advocates within the Eisenhower Administration but never clearly articulated, and it is unsurprising that it was France – itself on the cusp of becoming a nuclear power in 1958 – that enunciated it. More surprising was Eisenhower's response to de Murville. Referring to the peaceful tests he had rejected the day before, Eisenhower said that U.S. scientists "feel that revolutionary advances in this field can be made through testing" and that they were opposed to the moratorium for this reason; the president, however, felt that there was greater promise in the Geneva negotiations and that suspension of testing would offer the Soviet Union an opportunity to "deliver" on its dubious proposal of March.[127] Nowhere in his comments with de Murville was the prevarication on peaceful nuclear tests Eisenhower had shown in the previous days; but instead the president outlined a conception of the moratorium as a political measure of Soviet intentions. What the president did not say, and this author wonders if he contemplated, was that the United States had little to lose from a moratorium in August 1958. As Herter said, a moratorium of at least nine months would complement any test series of 1959, and as Eisenhower said to de Murville, in the absence of agreement with the Soviet Union, the United States would "be obliged to go as fast as we can in developing weapons" and thus resuming tests.[128] With its established lead in the development of nuclear weapons the United States could afford to suspend tests even if only to assess the credibility of the Soviet Union. At the very least, Washington was shifting the onus of responsibility back to Moscow just as Khrushchev had done to Eisenhower in March.

[127] Ibid.
[128] Ibid.

On 22 August 1958, Eisenhower announced the voluntary moratorium from the White House. He welcomed the successful conclusion of the Conference of Experts and their consensus regarding test detection (consensus that predated the complications from HARDTACK II). The president announced that the United States would "proceed promptly to negotiate an agreement with other nations" for the suspension of nuclear tests based on the conclusions of the Panel of Experts, and that

> in order to facilitate the detailed negotiations the United States is prepared, unless testing is resumed by the Soviet Union, to withhold further testing on its part of atomic and hydrogen weapons for a period of one year from the beginning of the negotiations [31 October 1958].[129]

On the same day, Eisenhower wrote to Norris Bradbury and Edward Teller as the directors of the Los Alamos and Lawrence Livermore laboratories to inform them of the suspension of testing for one year and "under certain conditions of progress toward real disarmament" on a year-by-year basis after that.[130] Jacqueline Bird briefly mentions Teller's reaction to this letter from the president, which must surely have been the physical embodiment of all that Teller had railed against in the preceding four years.[131] Despite his, the JCS, Strauss and later McCone's part in the parochial, domestic debate, the test moratorium had come to fruition.

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[129] The White House, Statement by the President, 22 August 1958; Speech Series, Box 27; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

[130] Bradbury's response was a curt and delayed one, but Teller's was more fulsome. He concluded with some passive-aggressiveness by saying that "in the meantime we are going to work vigorously under the limitations imposed on us by the present moratorium." Letter to Dr. Bradbury from President Eisenhower and Letter to Dr. Teller from President Eisenhower, 22 August 1958, also Letter to President Eisenhower from Edward Teller, 28 August 1958, also Letter to President Eisenhower from N.E. Bradbury, 18 September 1958; all within Subject Series, Box 9; Eisenhower, Dwight D.: Records as President, White House Central Files (Confidential File); Dwight D. Eisenhower Library.

[131] Bird noted that because of the moratorium Teller "now faced the major challenge of holding his laboratory [Lawrence Livermore] together." Bird, *Scientists in*

The path to the test moratorium was an illustrative one for the study of nuclear testing. Beginning in 1954 it was an extension of the efforts of Vannevar Bush at the end of the Truman Administration and, championed now by AEC commissioner Thomas Murray, sought to ban tests of hydrogen bombs. In that year came CASTLE BRAVO, the highest yield test ever conducted by the United States and also the worst incident of radiological contamination in the history of U.S. nuclear testing. BRAVO brought the issue of fallout into the public consciousness, and that consciousness was sharpened by the election campaign of 1956 when Adlai Stevenson campaigned for a test ban. Stevenson inevitably politicised an important international issue, which prevented an early effort to negotiate a cessation agreement with the Soviet Union. Nonetheless, his efforts helped build public support for test suspension, while the widening of Eisenhower's science advice following Sputnik in 1957 helped the president build support within his administration. The Soviet Union's unilateral suspension in March 1958 pressured the United States further and, although not entirely genuine, was probably as important a catalyst for the U.S. announcement of 22 August as any of the aforementioned. Along the path to the moratorium, both advocates and opponents laid out arguments that communicated reasons the United States conducted nuclear tests. Foremost was technological development: that testing was crucial for the United States to maintain its superiority in nuclear weapons over the Soviet Union, which could otherwise catch up during a moratorium through either theoretical development that could be confirmed by breaking the moratorium or through clandestine testing. Of the many imminent technological developments highlighted by opponents of the moratorium, the AICBM and clean warhead were dearest. Advocates of the moratorium demonstrated that the first, the AICBM, could

Conflict: Hans Bethe, Edward Teller and the Shaping of United States Nuclear Weapons Policy 1945-1972: 124.

not be improved through nuclear testing; while the second, the clean warhead, was an ultimately ineffective response to the more convincing argument of the dangers of radiation associated with atmospheric testing. Technological development of nuclear weapons through continued testing was so broad a field of discourse within the Eisenhower Administration that it touched upon all three of the core issues related to the moratorium: the danger of radiation, the ability to detect tests, and the national interest.[132] Following Eisenhower's announcement of 22 August, the United States had only five weeks to further develop its weapons before the moratorium took effect.

Accelerated Testing in October and November 1958

In Chapter Three, I argued that the United States cynically accelerated its test schedule in the last months before the moratorium. Operation HARDTACK Phase II was planned in November 1957 to include only two or three test shots, but as the moratorium became a firmer reality the series was expanded twice in August, again in September, and again in October 1958, and it eventually included twenty nuclear shots and eighteen safety shots.[133] This acceleration was a characteristic natural to the imminent deadline of the moratorium: for the AEC and Department of Defense, more tests furnished more data to study during the period of test suspension, while for Eisenhower and moratorium advocates, it was an affordable price to pay for that period of suspension. But it was not a characteristic unique to the United States.

After its unilateral suspension in March, the Soviet Union resumed testing at the end of September and in the two weeks between 30 September and 13 October the Soviet Union conducted nine nuclear tests that were detected by the United States.

[132] Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960*: 184.
[133] See Chapter Three for details on this expansion, which continued up until the week the moratorium took effect.

Director of the CIA, Allen Dulles, reported to the NSC that these were mostly airbursts and varied in yield between 5 kilotons to "more than 2 megatons," and were conducted – Washington believed – to demonstrate weapons for stockpile, reduce the weight of designs, or as "an over-all technological motivation to improve the Soviets' relative position."[134] Allen Dulles reported a further eight tests to the NSC on 30 October, bringing the total Soviet tests for that month to seventeen – still fewer than HARDTACK II, but nonetheless conducted "with terrific speed and in what appeared to be rather haphazard fashion."[135] At least two of these tests were roughly twice the yield of any previous Soviet nuclear test, although the exact yields Dulles specified remain redacted.[136] Interestingly, McCone, who shared the opinion of the CIA that this Soviet series was "haphazard", said that the AEC "could not believe that the Soviets had learned very much with the kind of instrumentation they had been using in this recent series of tests."[137] If the United States was accelerating its nuclear tests before the moratorium to derive data to analyse during the period of suspension – data that would turn out to be crucial for the issue of test detection at the very least – then

[134] Discussion at the 382nd (Special) Meeting of the National Security Council, Monday, October 13, 1958; NSC Series, Box 10; Eisenhower, Dwight D.: Papers as President, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

[135] Discussion at the 384th Meeting of the National Security Council, Thursday, October 30, 1958; NSC Series, Box 10; Eisenhower, Dwight D.: Papers as President, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

[136] Ibid. For a analysis of Soviet nuclear testing, see Robert S. and Arkin Norris, William M., "Soviet Nuclear Testing, August 29, 1949 - October 24, 1990," *Bulletin of the Atomic Scientists* 54.n3, no. May-June (1998). Although this article does not specify the yield of the Soviet tests of October 1958, it does list the six highest yield tests ever conducted by Moscow, among which the October 1958 tests do not number. They were thus probably less than 10 megatons.

[137] Discussion at the 384th Meeting of the National Security Council, Thursday, October 30, 1958; NSC Series, Box 10; Eisenhower, Dwight D.: Papers as President, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

McCone's statement suggests that the Soviet Union had accelerated its own tests for very different reasons.

The Soviet diplomatic response to the moratorium hints at the motivation for its accelerated testing. On 25 October, over a month after the president's announcement of the voluntary moratorium, Eisenhower stated that despite the willingness of both the United States and United Kingdom to suspend testing from 31 October, the Soviet Union had not accepted the offer of the U.S. and U.K.[138] Indeed, the Soviet Union did not commit itself to stopping tests with the kind of public declaration that Eisenhower had made on 22 August. This was made clear when on 1 and 3 November Moscow conducted two further nuclear tests seemingly in violation of the moratorium, although John Foster Dulles conceded that the Soviet Union had not violated an agreement because it had not committed itself to that agreement. Eisenhower announced these tests on 7 November – one wonders whether this date was chosen deliberately to coincide with Soviet celebrations of the fortieth anniversary of the October Revolution. The president remarked that the Soviet tests had been conducted despite the commencement of negotiations in Geneva on 31 October, and that both the U.S. and U.K. had committed themselves to suspend testing even though they had been testing weapons at that time. Most crucial of the president's statement regarding Washington's obligations was that

> This action by the Soviet Union relieves the United States from any obligation under its offer to suspend nuclear weapons tests. However, we shall continue suspension of such tests for the time being, and we understand that the United Kingdom will do likewise. We hope that the Soviet Union will also do so. If

[138] The White House, Statement by the President, 25 October 1958; OF108-A Atomic Weapons, Atomic and Hydrogen Bombs (7), Box 451; White House Central Files, Official File, 1953-1961; Dwight D. Eisenhower Library.

> there is not shortly a corresponding renunciation by the Soviet Union, the United States shall be obliged to reconsider its position.[139]

Eisenhower never received a corresponding renunciation, but these two tests were the last the Soviet Union conducted while he was president. That the Soviet Union made no attempt to conceal them, and that Soviet negotiators at Geneva made major concessions only a week later, suggests that the "haphazard" and accelerated Soviet tests of October and November 1958 represented, in the words of Divine, "a final move in the Soviet war of nerves, intended only for its psychological impact on the West."[140] The notion that nuclear tests could fulfil diplomatic purposes is a notion that came to the fore under President Kennedy, and will be explored in Chapter Six. Although the moratorium was in effect after 3 November it was insecure and ultimately impermanent: the Soviet Union had not publicly renounced testing, and the United States thus felt itself relieved of the obligation to suspend testing, and these respective positions eventually led to a resumption of nuclear testing in 1961.

Conclusion

During the presidency of Dwight D. Eisenhower, the United States first accelerated its nuclear testing program but then voluntarily suspended those tests. The outcome that was the moratorium does not appear easily reconcilable with the preceding process of acceleration. But they were very much related and, at an abstract level, the acceleration and the suspension represented the parochial, domestic politics that acted *within* the Eisenhower Administration and which defined the two sides of

[139] The White House, Statement by the President, 7 November 1958; OF108-A Atomic Weapons, Atomic and Hydrogen Bombs (7), Box 451; White House Central Files, Official File, 1953-1961; Dwight D. Eisenhower Library.
[140] Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960*: 238.

the test ban debate. That U.S. nuclear testing had become so extensive and pervasive by 1958 further emphasises the achievement that was the test moratorium.

The debate over the test ban between roughly 1954 and 1959 also highlighted larger issues about nuclear weapons and their testing. Public understanding of fallout and its global health effects that emerged after the CASTLE BRAVO test posed important questions about the rationality and responsibility of the superpowers that possessed thermonuclear weapons, tested them, and exposed "the world's population to even a slight health hazard in the name of national security."[141] Similarly, the notion that a suspension of testing could function as a prelude for disarmament was connected to the notion that nuclear testing was a crucial and inimitable requirement of weapons development. Important thought these issues were, the parochial discourse within the Eisenhower Administration typically took place on the battlegrounds of the danger of fallout, the ability of the United States to detect nuclear tests, and the national interest.

In hindsight, the United States had probably achieved just about all it could hope for from nuclear testing at the time that it committed to the test moratorium, although this was less the case in 1958 as it was in 1961. With the exception of the AICBM, the U.S. lacked a specific objective that loomed on the technological horizon as the hydrogen bomb had done under Truman. Through the nuclear test series conducted between 1952 and 1958 the United States had developed a diverse and effective nuclear arsenal that included deliverable strategic and tactical weapons. It had also through weapons effects tests come to understand the very important results of high altitude and exoatmospheric nuclear explosions, including radar and radio blackouts and damage to space vehicles. Finally, the many safety shots conducted

[141] Ibid., 321.

during Eisenhower's tenure – tests of no or low nuclear yield conducted to confirm the safety of the devices for transport and in emergencies like an air crash – gave the United States increased confidence in its nuclear arsenal. One side of the test ban debate promised important developments through continued testing – such as the AICBM and nuclear weapons with greatly reduced fallout – but for various reasons these promises were misleading and sometimes illusory. The United States had in 1958 reached the point where continued testing would be of greater help to the Soviet weapons program than the American.[142] With the significant accomplishments of the nuclear test series before 1958, the United States could enter into a moratorium in that year with more assurance than at any time before then.

The great accomplishment of the test moratorium was to arrest, even temporarily, the looping drive for more and more nuclear tests. This drive had many sources. First, the expansion of U.S. testing under Eisenhower came mostly from a diversification of the purposes for such testing, which grew from weapons design to include weapons effects, troop training exercises, and safety tests. Some of these purposes could be accomplished together in one test, but others had competing requirements that necessitated separate tests. Second, information relevant to the monitoring of the test suspension or cessation agreement – such as the detection of underground or outer space tests – necessitated further testing to confirm or measure a theory that resulted from a previous series. This was an impetus not unlike the development of nuclear weapons design, particularly under Truman. Third, the desire of one side of the test ban debate to continue nuclear weapons development with

[142] This was the argument of James Killian. Memorandum for the President from John Foster Dulles, 30 April 1958; Dulles-Herter Series, Box 10; Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961 (Ann Whitman File); Dwight D. Eisenhower Library.

promises of clean weapons and defensive nuclear missiles obliged further testing. This latter reason best exemplifies Sagan's domestic politics or parochial model for nuclear weapons development, according to which internal actors within a government can affect important decisions of a state's nuclear weapons (and, in this case, testing) policy. That the moratorium arrested the impetus for continued nuclear testing is an accomplishment the significance of which cannot be overstated.

Ironically, the outlines of that moratorium were not essentially different from those of the Limited Test Ban Treaty of 1963. Atmospheric tests were suspended under the moratorium because of the relative ease of their detection, while the difficulties of detecting underground tests of a yield below a certain threshold meant that neither the United States nor the Soviet Union could be entirely sure that the other was not conducting clandestine testing. But in the absence of a treaty that codified this circumstance, or in the absence of a detection system such as that negotiated at Geneva concurrent to the moratorium, the danger always remained that one of those powers could at any time recommence nuclear testing. In addition to the potential for Soviet clandestine testing, Washington also feared that Moscow would use the moratorium to prepare an extensive test series, abrogate the moratorium, and quickly recommence nuclear testing. Exactly this latter fear was realised in 1961.

The negotiations at Geneva – the Conference on the Discontinuance of Nuclear Weapons Tests – continued through 1958 and 1959. The United States' voluntary moratorium was to end on 31 October 1959 but Eisenhower extended it to 31 December; on that day, the president ended the moratorium but pledged that the United States would not resume testing without prior notice. Negotiations made progress in the first months of 1959 until on 1 May a high-altitude U-2 spyplane piloted by Gary Powers was shot down by the Soviet Union over Sverdlovsk. After an embarrassing series of diplomatic blunders by the United States, the Soviet Union withdrew from the Paris summit between Khrushchev and Eisenhower and the Geneva negotiations became icy, leaving Eisenhower sombre and disillusioned. George Kistiakowsky recalled speaking to the president in the weeks after the incident:

> The President began to talk with much feeling about how he had concentrated his efforts the last few years on ending the cold war, how he felt he was making big progress, and how the stupid U-2 mess had ruined all his efforts. He ended very sadly that he saw nothing worthwhile left for him to do now until the end of his Presidency.[143]

With the looming collapse of the Geneva negotiations, it was only a matter of time until one side or the other, impelled by various structural reasons, resumed nuclear testing. As the first president limited by the Twenty-Second Amendment, Eisenhower left office on 20 January 1961 with a warning to the nation about the parochial interests of the military-industrial complex. On 1 September the Soviet Union resumed nuclear testing and the United States responded with its own test series two weeks after that. I turn to U.S. nuclear testing under President Kennedy in the next chapter.

[143] George B. Kistiakowsky, *A Scientist at the White House: The Private Diary of President Eisenhower's Special Assistant for Science and Technology* (Cambridge: Harvard University Press, 1976), 375. Quoted in Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960*: 314.

Chapter Five

Kennedy, 1961-1963

"On such short notice, however, these [test shots] would have to be on a 'go, no-go' basis – indeed, this would be the only purpose of the test since adequate diagnostic instrumentation could not be implaced [sic] and made operative in time."

Letter to McGeorge Bundy from Glenn T. Seaborg, 30 August 1961.

"With the completion of the current series, the United States will have more high yield high-altitude effects data than the Soviet Union…"

Letter to Robert McNamara from Gerald W. Johnson, 25 July 1962.

U.S. nuclear testing under Kennedy was an awkward but necessary accessory to the overall narrative of nuclear testing and nuclear weapons development. The test moratorium undertaken by Eisenhower and Khrushchev was an imperfect and impermanent solution to the complications of nuclear testing, and that moratorium was abrogated by the Soviet Union at the end of August 1961. What resulted was a rapid, spasmic set of tests by both Moscow and Washington that evolved, on the U.S. side, into the five test series examined in this chapter. This period of testing lasted almost exactly two years and concluded with the Limited Test Ban Treaty on 10 October 1963. These two years and five test series were a vigorous but unwieldy valediction to U.S. atmospheric nuclear testing.

The nuclear test series held under Kennedy, although brief, were nonetheless numerous and complex. U.S. nuclear testing was an essentially continuous affair from September 1961, when testing recommenced, through to October 1963, when atmospheric testing ended and the Limited Test Ban Treaty became effective. A total of 133 nuclear shots were fired during this period, more than four times the number of shots fired in the eight years of testing under Truman and almost ninety per cent of the total fired in the six years of testing under Eisenhower. Gone, however, were the easily distinguishable test series of the Truman and Eisenhower Administrations. Test series overlapped in time and space and this confluence complicates the historical narrative.

This fifth chapter examines those U.S. test series. The relationship between Operations NOUGAT, SUNBEAM, STORAX, DOMINIC and FISHBOWL was a byzantine one, and deserves some explication. Operations NOUGAT and STORAX were held at the Nevada Test Site between 1961 and 1963 and were so broad and interconnected that they were differentiated only by the end of the fiscal year. Shots fired before 30 June 1962 were part of NOUGAT, while shots fired after that date were part of STORAX.[1] Operation SUNBEAM was conducted at Nevada in July 1962 as part of STORAX, and is referred to in some documents as DOMINIC II. Simultaneously, Operation DOMINIC was held at the Pacific Proving Ground between April and November 1962. Carried out within the frame of DOMINIC was Operation FISHBOWL.[2] NOUGAT, STORAX and SUNBEAM can be separated from DOMINIC and FISHBOWL by their location; while SUNBEAM can be discriminated from STORAX, and FISHBOWL from DOMINIC, because these

[1] Subject: MERRIMAC Event, 17 July 1962; Subjects, Reference Copy, Box 301; National Security Files; Papers of President Kennedy; John F. Kennedy Library.
[2] FISHBOWL was a series of high altitude tests not dissimilar from NEWSREEL within HARDTACK I in 1958.

subseries were conducted as Department of Defense weapons effects tests rather than weapons development tests.[3]

Because of this interrelationship, then, this chapter will be structured differently from Chapters One and Three. Rather than explore each test series separately and in turn, as was the case in previous chapters, this fifth chapter shall be structured by tests held at the Nevada Test Site and tests held in the Pacific. Because NOUGAT and STORAX were so closely related they shall be examined together, with SUNBEAM as the bridge between.

Nuclear testing under Kennedy took place in a context different to that of Truman and Eisenhower. The moratorium had shown that testing could be controlled and even abandoned, and the tests held under Kennedy contrasted to this example of restraint. Certainly, testing during this period would end with a more rigorous and durable system of prevention than that which had ended testing in 1958. But preceding that test ban treaty were two years of underground and atmospheric testing that spanned the deepest crisis of the Cold War – the Cuban Missile Crisis. More to the point, the test moratorium also acted to make the division between the Eisenhower and Kennedy Administrations all the more pronounced, especially in the field of nuclear strategy.[4] This was a discursive distinction that the uninterrupted test series of the early 1950s had helped to bridge between Truman and Eisenhower.

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[3] Even this relationship has been simplified: some sources refer to shots added to STORAX as STORAX II and even STORAX III, while joint U.S.-U.K. tests held as part of STORAX were technically part of Operation ROLLER COASTER. This thesis refers to each of these as part of STORAX.

[4] Much good work has been written about the Kennedy Administration's shift to a focus on limited, tactical nuclear war, flexible response and eventually graduated deterrence. For a good overview, see chapter fifteen of Freedman, *The Evolution of Nuclear Strategy*: 215-31. For a good account of the effect of the interaction between operational plans, political crises and technical developments upon nuclear strategy under Kennedy, see chapter nine of Burns, *A Global History of the Nuclear Arms*

NOUGAT, SUNBEAM and STORAX

The three test series NOUGAT, SUNBEAM and STORAX consisted together of 97 nuclear shots that were held essentially continuously between September 1961 and June 1963. All shots – with one exception – were fired at the Nevada Test Site, and for this reason shall be explored together in this chapter. Most were underground shots but not all.

Operation NOUGAT was the hurried response to the resumption of testing by the Soviet Union. Moscow had announced its decision to abandon the test moratorium and resume nuclear testing on 30 August 1961, two weeks after construction began on the Berlin Wall. It conducted its first test, an atmospheric shot that yielded 150 kilotons of TNT equivalent, two days later.[5] Glenn Seaborg, the chairman of the Atomic Energy Commission (AEC) under President Kennedy, gives an excellent account of the United States' rush to respond.[6] In a letter to national security advisor McGeorge Bundy, Seaborg lamented that the only tests that could be conducted on such short notice were "go, no-go" shots (meaning proof tests of new weapons) and that little data could be garnered from such tests because diagnostic equipment could

Race: Weapons, Strategy, and Politics, 1: 257-88. Campbell Craig argues that, despite its efforts and intentions, the Kennedy Administration was unable to shift away from the strategy and policies of the Eisenhower era until at least 1962. See chapter eight of Craig, *Destroying the Village: Eisenhower and Thermonuclear War*: 121-36.

[5] Seaborg, *Kennedy, Khrushchev, and the Test Ban*: 81-85.

[6] Glenn T. Seaborg was a remarkable figure in American science. He shared the Nobel Prize in Chemistry in 1951 for his work with transuranic elements, and was chairman of the AEC between 1961 and 1971. Seaborg also advised U.S. leaders on issues related to nuclear weapons and their control throughout the Cold War and into the post-Cold War world. His memoir of the test ban negotiations includes a detailed account of the American response to the Soviet resumption of testing. See chapter six of ibid., 81-92. This response will be further examined in Chapter Six of this thesis.

not be installed.[7] It was under these circumstances that Operation NOUGAT commenced two weeks later, and eventually included forty-five shots.

The United States began testing on 15 September with an underground shot that was expected to yield 2 kilotons but possibly yielded 6 kilotons.[8] This was the ANTLER shot of Operation NOUGAT.[9] Despite its relatively modest yield and underground location, ANTLER released radiation that was detected offsite. This was the start of a trend; altogether, twenty-seven shots of the NOUGAT series, or sixty-per cent, vented radiation into the atmosphere, although only eight of these released radiation that was detected offsite.[10] This venting clearly contradicted Kennedy's announcement on 5 September of the resumption of testing, which promised that there would be "no fallout" from the underground shots.[11] This consistent though accidental release of radiation from underground tests speaks to the hastened preparations for NOUGAT.

The NOUGAT shots were largely weapons related tests, as Seaborg had articulated to Bundy in September 1961. Many of the experiments held in the first half of 1962 were "designed to further [U.S.] understanding of the behaviour of fission assemblies," for either low-yield fission devices or the triggers for high-yield

[7] Ibid., 87.
[8] Ibid., 89.
[9] The Department of Energy and Carter and Moghissi put the yield of ANTLER at 2.6 kilotons, which contradicts Seaborg's testimony. ANTLER is one of the only shots in the series for which the yield is specified rather than given as a range. It seems more likely that the yield was 2.6 kilotons and that Seaborg's recollection is incorrect or overly-dramatic. "United States Nuclear Tests: July 1945 through September 1992," 16-17 and Melvin W. Carter and A. Alan Moghissi, "Three Decades of Nuclear Testing," *Health Physics* 33 (July 1977): 62.
[10] Ibid., 16-23.
[11] Seaborg, *Kennedy, Khrushchev, and the Test Ban*: 89.

thermonuclear devices.[12] At least two shots of the series, however, were weapons effects tests and were supported by the Department of Defense. These were the HARD HAT and DANNY BOY shots, fired in February and March, respectively. HARD HAT was an underground shot that yielded 5.7 kilotons and was fired at a depth of 965 feet (294 metres) in granite to determine the shock effects of a nuclear detonation in hard rock.[13] DANNY BOY was a cratering shot that was "neither confined completely underground nor purely atmospheric" and so "could be classed in either category."[14] DANNY BOY yielded 430 tons of TNT equivalent and was distinct from the previous cratering, weapons effects tests of Operation JANGLE of 1951 in that DANNY BOY was detonated in a different medium – "hard dry rock" – and measured the "containment and localization of radioactivity" afforded by that medium, and probably also the seismic signal produced.[15]

Also conducted as part of Operations NOUGAT and STORAX were two shots of Project Plowshare, a program that explored the peaceful uses of nuclear explosions, including construction of underground facilities, accessing deeply buried oil and natural gas deposits, creating new isotopes for scientific and medicinal research, and

[12] Letter to President Kennedy from Glenn Seaborg, 10 January 1962; Subjects, Reference Copy, Box 299A; National Security Files; Papers of President Kennedy; John F. Kennedy Library.

[13] Memorandum for the Secretary of Defense from Gerald W. Johnson, Assistant to the Secretary of Defense (Atomic Energy), 21 June 1962; Subjects, Reference Copy, Box 300; National Security Council Files; Papers of President Kennedy; John F. Kennedy Library and "United States Nuclear Tests: July 1945 through September 1992," 18-19.

[14] Letter to President Kennedy from Glenn Seaborg, 19 February 1962; Subjects, Reference Copy, Box 300; National Security Files; Papers of President Kennedy; John F. Kennedy Library.

[15] Memorandum for the Secretary of Defense from Gerald W. Johnson, Assistant to the Secretary of Defense (Atomic Energy), 21 June 1962; Subjects, Reference Copy, Box 300; National Security Council Files; Papers of President Kennedy; John F. Kennedy Library and "United States Nuclear Tests: July 1945 through September 1992," 18-19.

excavation. The first of these shots was GNOME, which was fired in December 1961. GNOME was described to Kennedy by Seaborg as “a multi-purpose experiment” that included as its objectives “the further development of several possible applications of nuclear explosives…specifically useful for peaceful purposes.”[16] GNOME was, indeed, intended to assist the design of nuclear explosives used for excavation as well as determine if the heat produced in an underground nuclear blast could be used for power generation, but also contributed “information of value to the weapons development program” and was planned so as not to interfere with the concurrent weapons test program.[17] GNOME involved the underground detonation of a low-yield device within a salt formation, and was conducted at a site near Carlsbad, New Mexico. GNOME was thus the first continental test held outside the Nevada Test Site since TRINITY in 1945. GNOME was expected to yield “about five kilotons” but yielded only 3 kilotons.[18] Despite its detonation at a depth of 1,200 feet (365 metres), GNOME was one of the aforementioned shots that vented radioactive materials detectable offsite.

The second of the Project Plowshare shots was SEDAN, which was fired in July 1962. SEDAN was added to the test program in May while NOUGAT was underway and, like GNOME, it was intended to measure blast effects of both “large-scale earth-moving projects” and ground-penetrating weapons.[19] SEDAN was a

[16] Letter to President Kennedy from Glenn Seaborg, 12 October 1961; Subjects, Reference Copy, Box 299A; National Security Files; Papers of President Kennedy, John F. Kennedy Library.
[17] Ibid.
[18] Ibid and "United States Nuclear Tests: July 1945 through September 1992," 16-17.
[19] Letter to McGeorge Bundy from Leland J. Howarth, 4 May 1962; Subjects, Reference Copy, Box 300; National Security Files; Papers of President Kennedy; John F. Kennedy Library.

thermonuclear device with a relatively clean fission yield of less than thirty per cent.[20] The AEC nonetheless anticipated due to its yield that SEDAN would vent radioactive material, and suggested that a delay of two months would permit the use of “a much cleaner device” that “would reduce the amount of vented radioactivity by a factor of 20.”[21] The test was nevertheless conducted in July with the dirtier device – SEDAN was fired at a depth of 650-700 feet (198-213 metres) and yielded 104 kilotons, the second largest device ever tested in the continental United States.[22] It created a crater 1,280 feet (390 metres) in diameter and 320 feet (97 metres) deep, and, like GNOME, released radioactive material detected offsite.

Because SEDAN was conducted after 30 June 1962 it was considered part of Operation STORAX rather than NOUGAT, even though it was held less than a week after the preceding Nevada test, NOUGAT SACRAMENTO.[23] The first stage of the United States’ return to nuclear testing had ended, and it was an inauspicious thing: despite Kennedy’s promises to the American people, and despite being an almost exclusively underground series, sixty per cent of the NOUGAT shots had spread radioactive material into the atmosphere and eight shots had vented radioactivity outside the Nevada Test Site. Little was learned except that devices designed and built during the moratorium did or did not function; indeed, the notable shots of the series, those of Project Plowshare, were neither exclusively peaceful tests nor did they contribute much new data to weapons effects studies. But the United States had

[20] "United States Nuclear Tests: July 1945 through September 1992," 24-25.
[21] Letter to McGeorge Bundy from Leland J. Howarth, 4 May 1962; Subjects, Reference Copy, Box 300; National Security Files; Papers of President Kennedy; John F. Kennedy Library.
[22] Ibid and "United States Nuclear Tests: July 1945 through September 1992," 24-25.
[23] Because NOUGAT was followed by SUNBEAM and because SEDAN was a similar test to GNOME, I have included SEDAN with NOUGAT even though it was by technicality a part of STORAX.

responded quickly to the Soviet resumption of testing – probably the defining feature of NOUGAT, and one better explored in the next chapter. As the fiscal year ended with June, NOUGAT rolled seamlessly into Operation STORAX.

STORAX was a fifty-two shot test series held between July 1962 and June 1963. Like NOUGAT, STORAX was an extensive, relatively low yield, underground series of weapons design tests. Most notable of these tests were the shots of the SUNBEAM subseries, a set of four shots conducted over ten days in July 1962. SUNBEAM was distinguished from STORAX by its sponsor, purpose and testing medium: it was a Department of Defense weapons effects series that was fired above ground.[24]

SUNBEAM commenced with the shot LITTLE FELLER II on 7 July, a shot for which Kennedy personally had shown some curiosity. In a meeting with Glenn Seaborg and Roswell Gilpatric, the deputy secretary of defense, Kennedy "expressed an interest in having an operational test made of the Davy Crockett weapon."[25] LITTLE FELLER II was the first test of that weapon "under simulated tactical conditions."[26] The Davy Crockett was a man-portable, low-yield, tactical nuclear weapons system for which Kennedy had an expected interest given his

[24] SUNBEAM is designated in the contemporary literature as DOMINIC II to differentiate it from the DOMINIC tests held simultaneously in the Pacific; this thesis adopts the later name of SUNBEAM used by the Department of Energy.

[25] Memorandum of the President's Decisions at the Meeting on Nuclear Weapons Requirements on May 3, 1962; Subjects, Reference Box 104; President's Office Files; Papers of President Kennedy; John F. Kennedy Library.

[26] Jean Ponton et al., "Operation DOMINIC II: Shots LITTLE FELLER II, JOHNIE BOY, SMALL BOY, LITTLE FELLER I 7 July - 17 July 1962," in *United States Atmospheric Weapons Tests Nuclear Test Personnel Review* (Washington, D.C.: Defense Nuclear Agency, 1983), 1.

administration's emphasis upon limited war and flexible response.[27] LITTLE FELLER II detonated with a low yield, likely a subkiloton yield.[28] Weapons effects studied at this shot included "blast, shock, cratering, prompt nuclear radiation, and fallout effects of a low-yield detonation."[29] Some of these effects were observed with specific reference to armoured vehicles: five tanks, previously used in the HARDTACK tests of 1958, were instrumented and exposed to the blast.[30] Suggested here was an awareness that weapons such as the Davy Crockett could be used against Soviet armour.

LITTLE FELLER II was followed within a week by shots JOHNIE BOY and SMALL BOY. Both were subkiloton yield detonations, but each tested different weapons effects.[31] JOHNIE BOY was another cratering experiment in a history of such experiments dating back to 1951 but with an emphasis upon measuring the distribution of debris and permanent ground deformation that resulted from the

[27] Indeed, in the same meeting in which he expressed interest in a test of the Davy Crockett, Kennedy "urged the completion…of the reappraisal of tactical nuclear weapons" that he had previously requested of the Department of Defense. Memorandum of the President's Decisions at the Meeting on Nuclear Weapons Requirements on May 3, 1962; Subjects, Reference Box 104; President's Office Files; Papers of President Kennedy; John F. Kennedy Library.

[28] Many of the tests conducted at Nevada under Kennedy have yields recorded not as specific figures but rather as ranges, and this remains the case even in the Department of Energy data. LITTLE FELLER II was classed as "low" yield, meaning "less than 20 [kilotons]." "United States Nuclear Tests: July 1945 through September 1992," x, 24-25. This bracket is particularly misleading in the case of the Davy Crockett warheads, which possessed subkiloton yields.

[29] Ponton, "Operation DOMINIC II: Shots LITTLE FELLER II, JOHNIE BOY, SMALL BOY, LITTLE FELLER I 7 July - 17 July 1962," 75.

[30] Ibid., 77-78.

[31] JOHNIE BOY is the only test of the SUNBEAM series attributed a specific yield of half a kiloton. Ibid., 93-94; "United States Nuclear Tests: July 1945 through September 1992," 24-25.

crater.[32] SMALL BOY, meanwhile, measured electromagnetic pulse effects similar to those observed in the high altitude series held before the test moratorium. As part of this study, two B-52 strategic bombers each bearing two stand-off, air-launched cruise missiles flew over the SMALL BOY site at the time of detonation in order to observe the effects of nuclear radiation and electromagnetic pulse upon that missile system.[33] Interestingly, vented radiation from the large SEDAN test – which was conducted over a week before SMALL BOY– affected some of the ground-based instruments installed for SMALL BOY.[34]

The final test of SUNBEAM was shot LITTLE FELLER I. This shot was a complete test of the Davy Crockett weapons system that involved the launch of a warhead from a rocket launcher mounted atop an armoured personnel carrier.[35] Conducted as part of this test was the military exercise IVY FLATS, which involved approximately a thousand soldiers who fired the Davy Crockett warhead and then conducted tactical manoeuvres near ground zero.[36] An operational test of a complete weapon system such as LITTLE FELLER I – including launch from a military vehicle

[32] "United States Nuclear Tests: July 1945 through September 1992," 94-99.
[33] Ponton, "Operation DOMINIC II: Shots LITTLE FELLER II, JOHNIE BOY, SMALL BOY, LITTLE FELLER I 7 July - 17 July 1962," 146.
[34] Ibid., 115-19.
[35] Ibid., 3.
[36] Although involving a smaller number of soldiers than the DESERT ROCK exercises of the Eisenhower years, IVY FLATS nonetheless appears to have been quite an intense exercise. It involved rifle platoons of a mechanised infantry battalion, supported by tanks, attack helicopters, artillery and conventional Davy Crockett rockets, attacking simulated enemy targets close to the LITTLE FELLER I detonation. Ibid., 156-67.

and the following troop exercise – was not possible with underground testing, an argument made by Seaborg in his recollections on the topic.[37]

STORAX shots were fired before, during, and for the most part after the SUNBEAM subseries. Already examined was SEDAN, the first shot of STORAX and the second of the Project Plowshare tests. STORAX MERRIMAC was fired on 13 July, between the SUNBEAM shots JOHNIE BOY and SMALL BOY.[38] MERRIMAC was an underground shot that was detonated at a depth of 1,370 feet (417 meters); almost two hours after the test the ground above the shot chamber subsided, forming a crater 600 feet (182 meters) in diameter and 40 feet (12 meters) deep.[39] MERRIMAC is recorded as having an intermediate yield, meaning anywhere between 20 and 200 kilotons – although the lower limit seems more likely given that vented radiation was not detected offsite as was the case with SEDAN.[40]

The remaining forty-six shots of STORAX were conducted after the completion of SUNBEAM, between July 1962 and May 1963. These shots were divided into phases and, interestingly, presidential approval for the series was given on a phase-by-phase basis. The first phase, STORAX I, covered those shots fired before 30 September; the second phases, STORAX II, covered shots between 1 October and 31 December; while the third phase, STORAX III, included all shots fired in 1963.[41] The first phase of the series was dominated by the SUNBEAM and

[37] Seaborg mentions three types of tests that could only be conducted above ground: high yield tests, tests "designed to prove the effectiveness of complete weapons systems," and anti-missile tests. Seaborg, *Kennedy, Khrushchev, and the Test Ban*: 90.
[38] Subject: MERRIMAC Event, 17 July 1962; Subjects, Reference Copy, Box 301; National Security Files; Papers of President Kennedy; John F. Kennedy Library and "United States Nuclear Tests: July 1945 through September 1992," 24-25.
[39] Ibid.
[40] "United States Nuclear Tests: July 1945 through September 1992," x, 24-25.
[41] Letter to President Kennedy from Glenn T. Seaborg, 28 September 1962; Carl Kaysen, Reference Copy, Box 376; National Security Files; Papers of President

Plowshare shots, together with a series of seven low yield weapons development tests.[42] The second phase was planned to include thirteen shots but to which a fourteenth shot was later added, and sought to develop “multipoint detonation systems,” “higher yield gun-type devices,” and reduce the vulnerability of devices, presumably to interference from nearby nuclear explosions or from premature detonation of a warhead’s conventional explosive lens.[43] The third phase continued the weapons development and safety tests, but involved novel experiments in which two devices were fired “approximately simultaneously so that only one seismic signal results”; this technique was used to reduce “observable off-site seismic signals resulting from weapons development experiments” and was a clear response to concurrent test ban negotiations.[44] Fired in this manner were shots ACUSHI and FERRET on 8 February 1963; shots KAWEAH and CARMEL on 21 February; shots KOONTANAI and PAISANO on 24 April; and shots HARKEE and TEJON on 17 May.[45] Tests held simultaneously enjoyed some degree of obfuscation: for example, according to a definition later agreed upon by the United States and the Soviet Union,

Kennedy, John F. Kennedy Library and Letter to McGeorge Bundy from Glenn T. Seaborg, 14 March 1963; Carl Kaysen, Reference Copy, Box 376; National Security Files; Papers of President Kennedy, John F. Kennedy Library.

[42] Seaborg wrote to Kennedy at the conclusion of STORAX I with a summary of its preliminary results, including the tantalising statement “[p]ossibly the most important achievement of STORAX I was the” – the remainder of that paragraph is redacted. Letter to President Kennedy from Glenn T. Seaborg, 28 September 1962; Carl Kaysen, Reference Copy, Box 376; National Security Files; Papers of President Kennedy, John F. Kennedy Library.

[43] Ibid.

[44] Letter to McGeorge Bundy from Glenn T. Seaborg, 14 March 1963; Carl Kaysen, Reference Copy, Box 376; National Security Files; Papers of President Kennedy, John F. Kennedy Library.

[45] The greatest margin of error between these simultaneous tests was 8.5 seconds between KAWEAH and CARMEL. HARKEE and TEJON were detonated precisely simultaneously. "United States Nuclear Tests: July 1945 through September 1992," 28-29.

KAWEAH and CARMEL were two separate tests while HARKEE and TEJON together constituted one test with two detonations.[46]

Operations NOUGAT and STORAX were the most extensive underground tests yet conducted by the United States. While they contributed information regarding weapons design and weapons effects, perhaps their most important contribution was proving the ability to conduct, however imperfectly, entire test series underground. Before NOUGAT, the United States' experience with underground testing was limited to a handful of shots, none earlier than PLUMBBOB RAINIER of 1957. NOUGAT and STORAX showed that an entire series of shots could be fired underground in such a way as to be relatively economical, to not affect one another, to contain radioactive materials, and to produce useful information. Such a demonstration possibly went some way toward assuaging concerns, particularly in the AEC, that the Limited Test Ban Treaty would retard U.S. nuclear laboratories.

With the conclusion of the SUNBEAM subseries, no further atmospheric tests were conducted at the Nevada Test Site; atmospheric testing continued with the concurrent DOMINIC series in the Pacific. I will return to the motivations behind the NOUGAT and STORAX series in the next chapter – but now explore the tests of Operation DOMINIC.

DOMINIC and FISHBOWL

Operation DOMINIC was the final atmospheric nuclear test series conducted by the United States before the Limited Test Ban Treaty banned atmospheric testing. DOMINIC was held between April and November 1962 and consisted of thirty-six

[46] See Protocol 2 of Section I of "Treaty Between The United States of America and The Union of Soviet Socialist Republics on the Limitation of Underground Nuclear Weapon Tests (and Protocol Thereto)."

shots. In contrast to NOUGAT, DOMINIC was a measured, extensive and well-planned test series that included a number of important experiments. Nonetheless, Operation FISHBOWL – a subseries to DOMINIC – was also marred by remarkable technical malfunctions.

Operational planning for DOMINIC began some time around October 1961 in the weeks after the Soviet resumption of atmospheric testing and the rapid commencement of Operation NOUGAT. Robert S. McNamara, the secretary of defense, directed the Joint Chiefs of Staff (JCS) to prepare plans "on an urgent basis" for tests involving: "an air drop with appropriate instrumentation and sampling required for a proof test"; "operational test firings of the ATLAS, POLARIS and ASROC systems"; "high altitude effects tests at an overseas location"; and "weapons development tests" in association with the AEC.[47] Seaborg recounts the discourse within the Kennedy Administration that led to the decision to recommence atmospheric nuclear testing, and recounts also President Kennedy's resistance to atmospheric testing. On 1 November, Kennedy announced that the United States was preparing for atmospheric testing; he made the final decision to resume atmospheric testing on 13 November – one month after McNamara's memorandum was sent to the JCS.[48]

The DOMINIC shots were held in the Pacific and were split between Christmas and Johnston Islands. Neither Eniwetok nor Bikini was used in DOMINIC,

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[47] The memorandum also directed that "no public announcement [of these preparations] is desired," presumably for operational reasons but also because Kennedy had yet to make the final decision to resume atmospheric testing. Memorandum for the Chairman, Joint Chiefs of Staff from Robert S. McNamara, 12 October 1961; Subjects, Reference Copy, Box 299; National Security Files; Papers of President Kennedy, John F. Kennedy Library.

[48] See chapters eight through eleven of Seaborg, *Kennedy, Khrushchev, and the Test Ban*.

for reasons that shall be explored in the next chapter; for the purposes of this chapter it is sufficient to note that twenty-four airdrops were held near Christmas Island for exclusively weapons design purposes, while another five airdrops and five high-altitude, rocket-borne tests were held at Johnston Island for mixed weapons design and weapons effects purposes.[49] Finally, two weapons tests were conducted in the open ocean south west of San Diego (in a similar position to the WIGWAM test of 1955).[50]

These two open-ocean tests were shots FRIGATE BIRD and SWORDFISH, and were tests of complete delivery platforms – from launch “under conditions that might be encountered in time of war”[51] through to detonation – in a manner similar to LITLLE FELLER I during Operation SUNBEAM. FRIGATE BIRD and SWORDFISH were the response to McNamara’s directive of October 1961 to prepare for “operational test firings of the ATLAS, POLARIS and ASROC systems.”[52] FRIGATE BIRD was an operational test of the Polaris submarine launched ballistic missile system, and, significantly, was the first operational test both of that weapons system and of a U.S. strategic ballistic missile generally.[53] On 6 May, the *USS Ethan Allen* launched the missile from a position 1,500 nautical miles (2,790 kilometres)

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[49] Letter to President Kennedy from Glenn Seaborg, 12 April 1962; Subjects, Reference Copy, Box 300; Papers of President Kennedy, John F. Kennedy Library and Berkhouse, "Operation DOMINIC I - 1962," 1. For a history of the U.S. Air Force’s involvement in DOMINIC operations, see Walter J. Boyne, "Big Bang," *Air Force Magazine*, no. December 2012.
[50] Berkhouse, "Operation DOMINIC I - 1962."
[51] Ibid., 184.
[52] Memorandum for the Chairman, Joint Chiefs of Staff from Robert S. McNamara, 12 October 1961; Subjects, Reference Copy, Box 299; National Security Files; Papers of President Kennedy, John F. Kennedy Library.
[53] The Polaris had been deployed since 1957 and each of its systems had been tested separately. Underwater launches of the Polaris had taken place but none had ended with the detonation of a warhead. Berkhouse, "Operation DOMINIC I - 1962," 184.

east-northeast of Christmas Island; the missile travelled 1,020 nautical miles (1,890 kilometres) toward the island and detonated as an airburst. FRIGATE BIRD yielded between 200 and 1,000 kilotons of TNT equivalent.[54] The objective of FRIGATE BIRD was to prove the efficacy of the Polaris system, "from launch through detonation," and as such, no experimental program was associated with the test.[55] The importance of FRIGATE BIRD was that it proved the deliverability of submarine launched ballistic missiles in the same way that REDWING CHEROKEE proved the deliverability of thermonuclear bombs from strategic bombers in 1956. Indeed, FRIGATE BIRD is described as the "capstone" to the Polaris missile system, and the test proved that the submarine "had joined the long range manned bomber and the land-based intercontinental ballistic missile force to form the three legs of the deterrent triad."[56]

Shot SWORDFISH followed FRIGATE BIRD less than one week later and involved an operational test of the Asroc nuclear anti-submarine rocket. SWORDFISH was planned to be held between Christmas and Johnston Islands, but commercial fishing in the area forced the test to be moved to a position 370 nautical miles (685 kilometres) south-west of San Diego, in the general area of the WIGWAM test.[57] On 11 May, the *USS Agerholme* launched an Asroc rocket at a target raft, which then detonated with a low yield at a depth of 750 feet (228 metres) underwater.[58] The explosion generated a spray dome 1,000 yards (914 metres) in

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[54] "United States Nuclear Tests: July 1945 through September 1992," 20-21.
[55] Berkhouse, "Operation DOMINIC I - 1962," 184, 95.
[56] Ibid., 184.
[57] Ibid., 196, 99.
[58] DOMINIC SWORDFISH was the fifth U.S. underwater nuclear test, after CROSSROADS BAKER (1946), WIGWAM (1955) and shots WAHOO and UMBRELLA of HARDTACK I (1958). "United States Nuclear Tests: July 1945 through September 1992," 2-21.

diameter and 750 feet (229 metres) in height, and radioactive plumes erupted from this dome to a maximum height of 2,100 feet (610 metres).[59] As the spray dome collapsed it left behind a patch of foam on the surface that had a diameter of about 4,000 yards (3.6 kilometres) and remained visible for several hours after the test.[60] SWORDFISH involved a weapons effects program in addition to the proof test, although this effects program was not essentially different to that of WIGWAM: to determine the ability of submarine detection equipment to operate after an underwater nuclear detonation, and determine the radiation hazard posed to the delivery ship in the aftermath.[61] The proof test of the Asroc system and experience in its use became particular portentous six months after SWORDFISH when U.S. destroyers equipped with the system grappled with Soviet submarines in the seas around Cuba.

Most dramatic of the DOMINIC shots were those that belonged to the subseries Operation FISHBOWL. FISHBOWL was to DOMINIC what NEWSREEEL was to the HARDTACK I series of 1958: a subset of high altitude weapons effects tests sponsored by the Department of Defense that focused upon effects experiments related to the interception of ballistic missiles or the penetration of a Soviet anti-ballistic missile system. FISHBOWL, then, was an extension of the high altitude tests in the HARDTACK and ARGUS series – moreover, with the imposition of the Limited Test Ban Treaty, FISHBOWL would be the climax of those experiments.

[59] Berkhouse, "Operation DOMINIC I - 1962," 207.
[60] SWORDFISH also generated a radioactive base surge that was larger but less visible than the foamed water. Ibid., 207-9.
[61] Appendix B to Proposed Atmospheric Test Program, 16 February 1962; Carl Kaysen, Reference Copy, Box 376; National Security Files; Papers of President Kennedy, John F. Kennedy Library.

While the DOMINIC series was publicly announced in March, no announcement was made about the FISHBOWL tests until late May.[62] In April, Najeeb Halaby, the administrator of the Federal Aviation Administration, enquired about the impact of high altitude tests on civil aviation. Seaborg appreciated Halaby's concern, and authorised him to disclose, "to the various domestic and foreign air carriers which would be concerned," that "a few detonations are planned."[63] Public announcement of FISHBOWL was made on 28 May, and this statement immediately recognised the similarity between the upcoming series and the TEAK and ORANGE shots of 1958.[64]

The many technical problems that disrupted the series constituted an important part of FISHBOWL. The series began inauspiciously on 2 June with the BLUEGILL shot. A liquid-fuelled Thor missile was launched from Johnston Island after midnight and, although it was later believed to be on a correct trajectory, tracking radar lost the

[62] At a meeting of the NSC Committee on Atmospheric Testing Policy that decided the announcement of DOMINIC, mention of announcing FISHBOWL was limited to "[h]igh altitude test will be announced in time to warn viewers in Hawaii, with appropriate description of phenomenology." Minutes of Meeting of NSC Committee on Atmospheric Testing Policy, 16 March 1962; Subjects, Reference Copy, Box 300; National Security Files; Papers of President Kennedy, John F. Kennedy Library.
[63] Letter to Najeeb E. Halaby from Glenn Seaborg, 19 April 1962; Subjects, Reference Copy, Box 301; National Security Files; Papers of President Kennedy, John F. Kennedy Library.
[64] AEC and DOD Announce High Altitude Tests, 28 May 1962; Subjects, Reference Copy, Box 300; National Security Files; Papers of President Kennedy, John F. Kennedy Library. However, a meeting on 25 May of the bulk of the NSC Committee on Atmospheric Testing Policy agreed that public announcement of FISHBOWL would be made "for the benefit of the scientific community." Record of Meeting on Nuclear Tests, 25 May 1962; Subject, Reference Copy, Box 300; National Security Files; Papers of President Kennedy, John F. Kennedy Library.

missile and "it was purposely destroyed for safety reasons."[65] There was no nuclear explosion, and the missile and its warhead were "lost by deep burial at sea."[66] Seaborg advised Bundy that BLUEGILL would be repeated.[67]

The unfavourable beginning to FISHBOWL soon grew worse. On 19 June, the second high altitude shot was attempted – shot STARFISH. Again a Thor missile was used, and again there was a technical problem, but this time more serious: after fifty-nine seconds of flight, one of the rockets cut out and the missile was destroyed. The missile was at an altitude of 30,000 to 35,000 feet (9.1 to 10.7 kilometres) when it was destroyed, and debris showered down on Johnston Island and in the surrounding water. Some of this debris was contaminated by plutonium from the fissile assembly.[68]

The two failed tests posed problems for the FISHBOWL schedule. In a meeting with his science advisors, McGeorge Bundy, McNamara, General Lemnitzer (chairman of the JCS) and Seaborg on 20 June, Kennedy announced his intent to complete FISHBOWL by 20 July, and concurred in the view that "the highest priority should be accorded" repeats of the failed BLUEGILL and STARFISH shots.[69] As a result of the delays imposed by the earlier failures, Kennedy was by this time

[65] Letter to McGeorge Bundy from Glenn Seaborg, 9 June 1962; Subjects, Reference Copy, Box 301; National Security Files; Papers of President Kennedy, John F. Kennedy Library and Berkhouse, "Operation DOMINIC I - 1962," 221, 27.
[66] Letter to McGeorge Bundy from Glenn Seaborg, 9 June 1962; Subjects, Reference Copy, Box 301; National Security Files; Papers of President Kennedy, John F. Kennedy Library.
[67] Ibid.
[68] Berkhouse, "Operation DOMINIC I - 1962," 228-29.
[69] Memorandum of the President's Decisions at the Meeting on Nuclear Tests on June 20, 1962; Subjects, Box 104; President's Office Files; Papers of President Kennedy, John F. Kennedy Library.

"reconsidering the necessity for conducting the Urraca [sic] test shot."[70] URRACA would indeed be cancelled, and its cancellation was tied to the progress of the other FISHBOWL shots.[71]

The second attempt of the STARFISH shot was held on 8 July and was known as STARFISH Prime. This second attempt was successful. STARFISH Prime was carried aloft by a Thor missile, which detonated 400 kilometres above Johnston Island and yielded 1.4 megatons.[72] This was the second-highest altitude nuclear shot conducted by the United States after ARGUS III of 1958.[73] The altitude and the yield of the STARISH Prime device generated widespread auroras visible across the Pacific area – in Hawaii, "an overcast, nighttime sky was turned into day for 6 minutes," while in Kwajalein "a spectacular display" lasting seven minutes was observed.[74] The DOMINIC test directors reported "a high degree of success for the scientific

[70] Ibid.

[71] McGeorge Bundy wrote a memorandum outlining the arguments for and against the URRACA shot two weeks after the meeting in which Kennedy began to reconsider the test. The crucial, and presumably deciding, point was that FISHBOWL was "running overtime" and that "on this basis it is Urraca [sic] we can do without." Ironically, Bundy wrote that URRACA was "probably the most failure-proof of the three high-altitude shots" – a desirable feature in a series marred by repeated failure. The Urraca Problem, 3 July 1962; Subjects, Reference Copy, Box 301; National Security Files; Papers of President Kennedy, John F. Kennedy Library.

[72] "United States Nuclear Tests: July 1945 through September 1992," 24-25; Berkhouse, "Operation DOMINIC I - 1962," 220.

[73] URRACA, the cancelled shot of FISHBOWL, was planned to have detonated at an altitude of 1,300 kilometers.

[74] Berkhouse, "Operation DOMINIC I - 1962," 229-30. While travelling in Turkey, this author had the fortune to meet a former diplomat from New Zealand who recalled as a child observing the effect of the Johnston Island high altitude tests. It seems most likely that he observed STARFISH Prime, whose effects were visible on both sides of the equator. He undoubtedly observed the auroral effects at the conjugate point in the South Pacific, rather than the direct glow that was observed in Hawaii. Hoerlin further discusses the STARFISH phenomenology. See Hoerlin, "United States High-Altitude Test Experiences: A Review Emphasizing the Impact on the Environment," 33-34.

programs" associated with STARFISH Prime.[75] But such was the scale and altitude of STARFISH Prime that an extensive, high-energy electron belt was created in Earth's Van Allen belt, damaging the solar cells of and ultimately disabling many satellites.[76] The damage to satellites prompted concerns about manned spaceflight, in its infancy in 1962. The Soviet Union was concerned about the safety of a cosmonaut in orbit a month after STARFISH Prime.[77] McGeorge Bundy responded to this and other anxieties in a memorandum to the president in late August. He noted that the high-energy electron belt created by STARFISH Prime was decaying; that the belt "created no radiation hazard to the recent Soviet orbital flights"; and that the belt would affect neither the forthcoming Mercury launch nor planned lunar exploration.[78] Indeed, such was the immaturity of the U.S. and Soviet space programs at this time that STARFISH Prime detonated several hundred kilometres above the orbits of Mercury or Vostok flights and affected neither.[79]

[75] DOMINIC Test Bulletin No. 42, Subject 1. STARFISH PRIME EVENT 2. LITTLE FELLER II EVENT, 9 July 1962; Subjects, Reference Copy, Box 301; National Security Files; Papers of President Kennedy, John F. Kennedy Library.

[76] Disabled satellites included Transit IV, TRAAC and Ariel, plus others. AEC-DOD Statement on Inner Radiation Belt, 20 August 1962; Subjects, Reference Copy, Box 300; National Security Files; Papers of President Kennedy, John F. Kennedy Library. Soon after the Test Ban Treaty, NASA conducted a study of the effects of high altitude nuclear explosions on the Van Allen belts, satellites and spacecraft. See Wilmot N. Hess, "The Effects of High Altitude Explosions," (Washington, D.C.: National Aeronatics and Space Administration, 1964).

[77] Seaborg, *Kennedy, Khrushchev, and the Test Ban*: 156.

[78] Memorandum for the President from McGeorge Bundy, 22 August 1961; Subjects, Reference Copy, Box 300; National Security Files; Papers of President Kennedy, John F. Kennedy Library.

[79] Mercury flew as high as 260 kilometers, well below the belt of electrons created by STARFISH Prime. Letter to President Kennedy from Glenn Seaborg and Robert McNamara, 6 September 1962; Carl Kaysen, Reference Copy, Box 376; National Security Files; Papers of President Kennedy, John F. Kennedy Library.

On 25 July, a second attempt was made to fire the BLUEGILL shot. This attempt was named BLUEGILL Prime, and was a more dramatic failure than the first. The Thor missile malfunctioned after ignition but before launch; again the missile was remotely destroyed. Although the warhead did not go critical, the explosion scattered radioactive material across the facility, while burning rocket fuel spread the contamination into service trenches.[80] BLUEGILL Prime put the Johnston Island launch facilities out of commission, which forced an operational pause as the facilities were decontaminated and repaired. The third attempt at the BLUEGILL test was named BLUEGILL Double Prime and was attempted on 15 October, eighty-two days after the failure of BLUEGILL Prime. BLUEGILL Double Prime again used a Thor missile, and, perhaps unsurprisingly, the Thor again malfunctioned ninety-five seconds after launch and was remotely destroyed.[81]

Despite five attempts, only one test of FISHBOWL had been successful, and, by the failure of BLUEGILL Double Prime, FISHBOWL had exceeded Kennedy's deadline of 20 July by almost three months. The president was unlikely to have had an opportunity to take issue with the failure, however: BLUEGILL Double Prime failed the same day that McGeorge Bundy briefed Kennedy that aerial reconnaissance photography had determined that the Soviet Union was installing nuclear missiles in Cuba.[82]

The U.S. did not cease nuclear testing during the thirteen days of the Cuban Missile Crisis, detonating four atmospheric shots associated with Operation DOMINIC. The first of these was DOMINIC CHAMA, an airdrop near Christmas

[80] Berkhouse, "Operation DOMINIC I - 1962," 222.
[81] Ibid., 223-41.
[82] BLUEGILL Double Prime was fired shortly before midnight on 15 October (local time); at which time it was early morning on 16 October on the east coast of the United States.

Island that yielded 1.59 megatons on 18 October; this was followed the next day by CHECKMATE, a successful, low yield, high altitude shot from Johnston Island that was only the second success of the FISHBOWL series.[83] BLUEGILL Triple Prime, the fourth attempt at the BLUEGILL shot, was successfully fired on 25 October. Even this overdue success was marred by complications: two personnel on Johnston Island received flash burns to their eyes as a result of the nighttime detonations, although neither resulted in permanent blindness.[84] The fourth of these tests was the appropriately named DOMINIC CALAMITY, an 800-kiloton airdrop shot over Christmas Island that was fired on 27 October – the tensest day of the Cuban Missile Crisis, the same on which one U.S. spy plane was shot down over Cuba and another strayed into Soviet airspace over Siberia.[85]

Operation DOMINIC concluded in November 1962 with two successful shots of FISHBOWL: KINGFISH, on 1 November, and TIGHTROPE, on 3 November. Thus ended U.S. atmospheric testing. The concurrent underground STORAX shots continued, but DOMINIC was the last atmospheric test series conducted before the Limited Test Ban Treaty took effect in 1963. The total yield of the series remains

[83] CHECKMATE detonated at an altitude of 147 kilometres and less than three miles (4.8 kilometres) from its predicted location. As with the other nighttime shots of FISHBOWL, there is some discrepancy in the dates of the tests, as various sources use either local time or the time in Washington. DOMINIC Test Bulletin No. 53 SUBJECT: CHECKMATE EVENT, 23 October 1962; Subjects, Reference Copy, Box 301; National Security Files; Papers of President Kennedy, John F. Kennedy Library and "United States Nuclear Tests: July 1945 through September 1992," 26-27.

[84] Neither of the men was wearing protective goggles at the time of the detonation. Both received permanent eye damage but were not blinded. Hoerlin, "United States High-Altitude Test Experiences: A Review Emphasizing the Impact on the Environment," 13-14; Berkhouse, "Operation DOMINIC I - 1962," 244.

[85] The CALAMITY test and its effect on the White House appear in the 2000 film *Thirteen Days*. CALAMITY also features in Michael Dobbs's account of the Cuban Missile Crisis. Michael Dobbs, *One Minute to Midnight: Kennedy, Khrushchev and Castro on the Brink of Nuclear War* (London: Hutchinson, 2008), 251-53.

unclear, largely due to the policy of the AEC during the Kennedy Administration to report the yields of some tests as a range rather than a specific figure. Seaborg states in his memoirs that the total yield of DOMINC was "held to approximately 20 megatons."[86] Simon and Robison have suggested that the total yield of DOMINIC was approximately 35.4 megatons, and, although they do not state it explicitly, it seems these authors totalled only those shots with specific yields, and ignored those reported as brackets.[87] The total yield of DOMINIC was in fact higher than both Simon and Robison's estimate and Seaborg's statement.

DOMINIC was clearly the valediction of U.S. atmospheric nuclear testing, which began seventeen years earlier with TRINITY. Ironically, this comprehensive test series coincided with the worst moments of the Cold War. On the day the United States came closest to nuclear war with the Soviet Union – 27 October 1962 – it dropped a submegaton-yield nuclear bomb from a B-52 bomber over Christmas Island. Yet, DOMINIC was an important test series and not because it was the last atmospheric series. Seaborg informed Kennedy that, through DOMINIC, the United States "verified the performance of several warheads which are now or soon will

[86] Interesting is Seaborg's hint of a desire to widen the yield and scope of DOMINIC through his use of the words "held to." Interesting also is his statement, immediately after that quoted above, that the Soviet test series of 1961 had a total yield "almost ten times as much" as DOMINIC. Seaborg, *Kennedy, Khrushchev, and the Test Ban*: 151.
[87] Simon, S.L. and Robison Simon, W.L., "A Compilation of Nuclear Weapons Test Detonation Data for U.S. Pacific Ocean Tests," *Health Physics* 73, no. 1 (1997): 263. These authors provide a yield total of 43 megatons for all tests held in the Pacific outside the Marshall Islands; subtracting the three shots of HARDTACK I, the remainder represents the DOMINIC shots and is 35.4 megatons. This figure is the same as the total of each DOMINIC shot reported with a specific yield. Using the upper limit of the range for those shots reported as such, the total yield of the series climbs to 38.5 megatons.

constitute a critical portion of our strategic weapons stockpile."[88] Moreover, with the completion of DOMINIC, the Department of Defense concluded that "the United States will have more high yield high-altitude effects data than the Soviet Union" – data that was particularly important for "penetration, weapon hardening, communications and radar blackout, and AICBM [anti-intercontinental ballistic missile] capability."[89] Furthermore, the DOMINIC tests had a dual effect on U.S. weapons laboratories: they vindicated "the elaborate computational and certification procedures" used by these laboratories during the moratorium, when testing of warheads was not possible; while at the same time "revitalized to a major degree" those laboratories, which had suffered personnel losses during the moratorium.[90]

Conclusion

The test series conducted under Kennedy were broad in scope, high in number, and concentrated in time, but were neither innovative nor far-reaching in effect. Nowhere to be seen were the significant technical developments on the Truman and Eisenhower years, where fission devices gave way to boosted fission and eventually fusion bombs, all of which were miniaturised and weaponised. Even the FISHBOWL tests, remarkable though they were, did not depart fundamentally from the high altitude HARDTACK I and ARGUS shots of 1958. Rather, the NOUGAT,

[88] Letter to President Kennedy from Glenn Seaborg, 10 August 1962; Subjects, Reference Copy, Box 301; National Security Files; Papers of President Kennedy, John F. Kennedy Library.
[89] Memorandum for the Secretary of Defense from Gerald W. Johnson, 25 July 1962; Subjects, Reference Copy, Box 300; National Security Files; Papers of President Kennedy, John F. Kennedy Library.
[90] Letter to President Kennedy from Glenn Seaborg, 10 August 1962; Subjects, Reference Copy, Box 301; National Security Files; Papers of President Kennedy, John F. Kennedy Library.

STORAX and DOMINC series contributed refinements to concepts and observations made in previous test series.

Although it is difficult to argue, it can be suggested that the brevity of testing under Kennedy was at least in part responsible for this developmental weaknesses. In preceding periods, test series built upon the results of their predecessors, ultimately driving both theoretical and practical knowledge toward dramatic and observable innovations. The constrained nature of the tests held between 1961 and 1962, however – combined with the inherently political nature of their recommencement – precluded this linear development. The effect was that what progress was made, particularly by FISHBOWL in the field of anti-ballistic missile effects and precursor blackout bursts, was not exploited to the noticeable extent that characterised the testing of the 1950s.

Nonetheless, there were strengths to the NOUGAT, STORAX and DOMINIC tests, and these were twofold. The first was the importance of complete tests of tactical and strategic nuclear weapons, including their delivery system. This kind of test was borne out in SUNBEAM LITTLE FELLER I, which tested the Davy Crockett nuclear rocket; in DOMINIC FRIGATE BIRD, which tested the Polaris submarine-launched ballistic missile; and in DOMINIC SWORDFISH, which tested the Asroc anti-submarine nuclear rocket. While elements of this system could be and were tested separately, only through atmospheric testing could the entire system be verified – and the period between 1961 and 1963 offered a brief window to do so. The second was the confirmation and refinement of those "computational and certification procedures" that Seaborg mentioned in August 1962: all the various mechanisms and techniques for estimating the effectiveness of weapons short of nuclear testing. Here again the period between 1961 and 1963 offered a chance to verify theory and practicality which in turn gave confidence that similar techniques would be effective under the Test Ban.

Finally, the tests conducted under Kennedy fundamentally proved the efficacy of the United States' nuclear arsenal. This point is an important one: through tests such as FRIGATE BIRD Washington gained confidence in its nuclear stockpile before it committed to the Limited Test Ban Treaty. It acquired experience with tactical nuclear weapons and with the firing of nuclear rockets. Moreover, the United States experimented with simultaneous underground detonations, a technique it feared the Soviet Union might use to obfuscate seismic monitoring of a test ban. In short, NOUGAT, STORAX and DOMINIC demonstrated that the U.S. nuclear arsenal was effective and that the Pentagon and the White House could have confidence in that stockpile going into the Test Ban – thus, these series achieved all Washington could realistically have hoped of them.

That being said, nuclear testing under Kennedy was largely undertaken for political reasons. Washington calculated that, once the Soviet Union abrogated the test moratorium, it could not be allowed to test unilaterally. There was an undeniable technical dimension to this perception – for example, a concern that Moscow might develop an effective anti-ballistic missile weapons as a result of high altitude tests – but there was also a political and propaganda dimension to matching the Soviet test series. An exploration of these two interrelated dimensions, as evidenced by White House discussions regarding the recommencement of nuclear testing, will be explored in the next chapter.

Chapter Six

The Limitation of Nuclear Testing

"The question of test resumption is one which must be considered almost totally in a political and psychological context rather than in terms of strategic technological considerations."

Memorandum for McGeorge Bundy from Marc Raskin, 25 July 1961.

"…nothing fundamental is likely to be changed by any amount of future nuclear testing."

Hans Bethe, lecture at Cornell University, 5 January 1962.

When John F. Kennedy was inaugurated as president in January 1961, the negotiations at Geneva toward a test ban – revitalised by the test moratorium, but stymied by profound disagreements over the inspection of potential underground tests – were in their twenty-seventh month. It had been almost sixteen years since the United States' first atomic test, but more than two years since the end of Operation HARDTACK Phase II. Concern regarding the health effects of global fallout had receded as the tests themselves stopped, but without progress at Geneva or a binding agreement to preserve the moratorium, the incentive to test nuclear weapons never really went away. Both Washington and Moscow considered the resumption of nuclear tests and, accordingly, less than nine months after Kennedy's inauguration, both the Soviet Union and United States had returned to nuclear testing, and their test series spanned the next two years and both the Berlin and Cuban Missile crises.

The nuclear tests conducted by the United States between 1961 and 1963 were a spasmic epilogue to the longer experience of testing ended by the moratorium. But these tests were nonetheless crucial: they demonstrated the effectiveness of the U.S. nuclear arsenal and its delivery through proof shots of stockpiled weapons, and they showed that entire test series could be conducted underground. Moreover, the circumstances surrounding the U.S. resumption of testing offer an example of the political motivations for nuclear testing, while the weapons effects studies of Operation DOMINIC acted to diminish institutional interest in anti-ICBM technology and, therefore, opposition from those same institutions to the Limited Test Ban Treaty (LTBT).

Literature dedicated to Kennedy and nuclear thought is generally focused on the doctrinal shift to flexible response, or the Cuban Missile Crisis of October 1962.[1] To a lesser extent, historians focus also on various aspects of the Limited Test Ban

[1] Of the doctrinal shift, see particularly Craig, *Destroying the Village: Eisenhower and Thermonuclear War*: 121-62; Freedman, *The Evolution of Nuclear Strategy*: 215-40; David G. Coleman, and Joseph M. Siracusa, *Real-World Nuclear Deterrence: The Making of Nuclear Strategy* (Westport: Praeger Security International, 2006), 121-62. Excellent accounts of the Cuban Missile Crisis include Dobbs, *One Minute to Midnight: Kennedy, Khrushchev and Castro on the Brink of Nuclear War*; G. Allison, and P. Zelikow, *Essence of Decision: Explaining the Cuban Missile Crisis*, 2nd ed. (New York: Longman, 1999). For the perspective of the American people during the crisis, see Marcus D. Pohlmann, "Constraining Presidents at the Brink: The Cuban Missile Crisis " *Presidential Studies Quarterly* 19, no. 2 (1989). For interesting and personal perspectives of the crisis, see Blema S. Steinberg, "Shame and Humiliation in the Cuban Missile Crisis: A Psychoanalytic Pespective," *Political Psychology* 12, no. 4 (December 1991); B. Gregory Marfleet, "The Operational Code of John F. Kennedy During the Cuban Missile Crisis: A Comparison of Public and Private Rhetoric," *Political Psychology* 21, no. 3 (September 2000). A good source for the relationship between nuclear weapons and the crisis is Marc Trachtenberg, "The Influence of Nuclear Weapons in the Cuban Missile Crisis," *International Security* 10, no. 1 (1985).

Treaty, particularly the leadership of President John F. Kennedy.[2] While these are important themes, missing entirely from the historiography is an appraisal of the U.S. and Soviet test series and how these influenced the LTBT and, also, each other. The memoirs of Glenn T. Seaborg, the chairman of the Atomic Energy Commission (AEC) under Kennedy, are particularly useful, as he provides a balanced and detailed account of the negotiations of the LTBT and discusses the interaction of testing and politics.[3] This chapter shall further explore that interaction by examining the relationship between the political and technical reasons for recommencing testing in 1961, and investigate how the results of the test series carried out under Kennedy affected thought on nuclear weapons and the test ban.

As with Chapters Two and Four, this chapter shall adapt to the field of nuclear testing one of the models presented by Scott D. Sagan to explain why nations pursue nuclear weapons. The third of Sagan's models is the "security model," whereby a nation develops nuclear weapons due to a perceived threat, almost always nuclear, to its security. This is perhaps the most basic and intuitive of his models but, as Sagan notes, also difficult to verify.[4] As the first nuclear power, the United States had always been technologically and theoretically ahead of other nuclear powers, but this situation was threatened in 1961. I argue that the security model is applicable to U.S.

[2] Examples include Andreas Wenger, and Marcel Gerber, "John F. Kennedy and the Limited Test Ban Treaty: A Case Study of Presidential Leadership," *Presidential Studies Quarterly* 29, no. 2 (1999); Theodore C. Sorenson, "JFK's Strategy of Peace," *World Policy Journal* 20, no. 3 (Fall 2003); McGeorge Bundy, "The Presidency and the Peace," *Foreign Affairs* 42, no. 3 (April 1964); Vojtech Mastny, "The 1963 Nuclear Test Ban Treaty: A Missed Opportunity for Détente?" *Journal of Cold War Studies* 10, no. 1 (2008).
[3] Seaborg, *Kennedy, Khrushchev, and the Test Ban*. The epilogue to Greene's work also discusses many of these issues. Greene, *Eisenhower, Science Advice, and the Nuclear Test Ban Debate, 1945-1963*.
[4] Sagan, "Why Do States Build Nuclear Weapons?: Three Models in Search of a Bomb," 57-63.

nuclear testing under Kennedy because, for the first time in its history, the American lead in nuclear technology was jeopardised by the circumstances in which the Soviet Union resumed nuclear tests. Actors within the Kennedy Administration – scientist and politician alike – perceived that the rapid resumption of a carefully and extensively prepared test series by the Soviet Union, contrasted with the ineffective response mustered by the United States with Operation NOUGAT, had substantially narrowed the advantage the United States enjoyed in nuclear weapons technology when it entered the moratorium. Perhaps at no other time since the early days of the Manhattan Project had the United States perceived such a threat to its *nuclear* security, and this perception lends significance to Sagan's security model when applied to testing under Kennedy.

In Chapter Five, I examined the three major test series and two sub-series carried out by the United States under Kennedy's brief presidency. This chapter shall survey the consequences of those series, including the political nature of the U.S. resumption of testing; the manner in which the results of U.S. and Soviet tests affected both perceptions of their relative power balance and attitudes toward a test ban; the effect these series had on the anti-ICBM (AICBM); and the final state of nuclear testing at the time of the LTBT. In so doing, it seeks not only to better contextualise the swansong to U.S. atmospheric testing that was seen between 1961 and 1963, but also to demonstrate that, more so than under Truman and Eisenhower, U.S. testing under Kennedy was motivated by a perceived threat to its security. How this threat was managed was crucial to the LTBT.

The United States Considers Resumption

In the absence of a diplomatic agreement with the Soviet Union banning tests or progress in negotiations to that effect, calls for the resumption of U.S. nuclear testing grew steadily more insistent in the first nine months of Kennedy's presidency. The sources of these arguments were not different from those that had opposed the test moratorium under Eisenhower: the Department of Defense, embodied by the Joint Chiefs of Staff (JCS), and to a lesser degree the Atomic Energy Commission (AEC), but added now was the National Security Council (NSC). The United States made modest moves toward resumption even before the Soviet Union recommenced testing, and Moscow's announcement on 30 August of its intention to resume testing bore out many of the warnings of test advocates, ensuring a response from Washington that had long been contemplated anyway. As the U.S. considered resumption in the first half of 1961, no conclusive technical arguments could be arrayed in favour of it; yet, the rapid progress achieved by a unilateral Soviet test series changed that, because U.S. nuclear superiority was for the first time imperilled.

Despite Kennedy's personal assurances to Eisenhower of his commitment to test cessation – before even receiving the Democratic nomination, for example, Kennedy wrote to Eisenhower to declare that, if elected president, he would "carry out in good faith" any suspension or cessation agreement negotiated under Eisenhower's tenure – the outgoing president was so disillusioned with the apparent failure of the Geneva negotiations that he advised Kennedy to recommence nuclear testing without delay.[5] Eisenhower apparently intended to order test resumption as

[5] Letter to President Eisenhower from Senator John F. Kennedy, 30 March, 1960; OF108-A Atomic Weapons, Atomic and Hydrogen Bombs (7), Box 451; Official File, 1953-1961; White House Central Files; Dwight D. Eisenhower Presidential

one of his final acts as president, had Richard Nixon won the 1960 election.[6] Kennedy resisted this advice and remained committed to the suspension of nuclear tests despite the end of the moratorium before he took office and the lack of commitment from the Soviet Union. But Eisenhower's was not the only voice advising resumption.

Within the context of Soviet intransigence at Geneva, the incoming administration discussed the resumption of nuclear testing and identified problems inherited from the Eisenhower Administration. At the end of April, an informal meeting on Contingency Planning for the Resumption of Nuclear Testing – attended by members of the NSC, the United States Information Agency (USIA), the CIA, Department of Defense, the Disarmament Commission, the chairman of the AEC, Glenn Seaborg, and the president's science advisor, Jerome Wiesner – discussed the stalled Geneva negotiations. Two core problems were identified: "which alternative to take to get off the hook," that is, to abrogate the suspension of testing, and "how soon."[7] Further enunciated, the problem was "no longer how to get a test ban treaty" because, after two and a half years of effort, the stalled negotiations suggested that the United States could not reach a satisfactory treaty, but rather how "to get off the hook of a self-imposed test ban on which the Soviets hope to keep [the United States]

Library; and Dwight D. Eisenhower, *Waging Peace, 1956-1961* (New York: Doubleday & Company, Inc., 1965), 481.

[6] This anecdote comes from Glenn Seaborg, who quotes Harold K. Jacobsen and Eric Stein. To this author, it profoundly affects Eisenhower's legacy but does show the depth of his disappointment in the final months of his presidency. Harold Karan and Eric Stein Jacobson, *Diplomats, Scientists, and Politicians: The United States and the Nuclear Test Ban Negotiations* (Ann Arbor: University of Michigan Press, 1966), 263; Seaborg, *Kennedy, Khrushchev, and the Test Ban*: 25.

[7] Memorandum for the Record, Informal Meeting on Contingency Planning for the Resumption of Nuclear Testing, 27 April 1961; Reference Copy, Box 439; Robert W. Komer; Papers of President Kennedy, National Security Files; John F. Kennedy Library.

impaled."[8] The most compelling reasons for resumption were not military but instead diplomatic. It was remarked by Robert Komer, who served on the NSC under McGeorge Bundy, that the resumption of testing was "not absolutely critical to our security"; he lamented that it were not, because, if it were, the "decision would be easy."[9] Instead, the recent Soviet propaganda victory of Yuri Gagarin's orbital flight (12 April) and the American defeat at the Bay of Pigs (19 April) had left the United States embarrassed, and the attendees of this meeting sought to convey to Khrushchev the risks of pushing the United States "too far" and Komer argued that the resumption of nuclear testing would serve this purpose.[10] Moreover, the resumption of testing was perceived to counteract the Soviet Union's misconceptions about the Kennedy Administration's shift away from too exclusive a nuclear doctrine toward flexible response.[11] Three options were considered in this meeting. First, to continue the voluntary suspension but to clearly announce a fixed deadline, after which testing would resume; second, to resume underground testing; and third, to begin with seismic research tests such as those proposed under Eisenhower to explore

[8] Subject: The Case for Resumption of Nuclear Tests, 28 April 1961; Reference Copy, Box 439; Robert W. Komer; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[9] Ibid.
[10] Ibid. This was a perception shared by the American press. Komer wrote to McGeorge Bundy only days later and noted that *The Washington Post* "decided we can't resume testing because it would give us too big a black eye, coming after Cuba." Memorandum for McGB from RWK, 1 May 1961; Reference Copy, Box 439; Robert W. Komer; Papers of President Kennedy, National Security Files; John F. Kennedy Library. At about this time, Robert Wilson, a commissioner of the AEC, made a public appeal for the resumption of underground weapons tests. See Robert E. Wilson, "The Need for the Early Resumption of Underground Nuclear Weapons Tests," *Proceedings of the American Philosophical Society* 105, no. 2 (April 1961).
[11] For an excellent account of this shift from New Look and massive retaliation to flexible response, see Craig, *Destroying the Village: Eisenhower and Thermonuclear War*.

decoupling.[12] The attendees concluded that "whatever we did we should not be the ones to break off Geneva talks" and that the onus for just that should be left to the Soviet Union.[13]

In May, the AEC recommended the second and third of these options. Seaborg wrote to John McCloy, Kennedy's advisor on disarmament, and recommended that "immediately after the termination of negotiations" at Geneva, or even "before that time," the United States begin underground tests for both weapons testing and seismic research purposes.[14] Seaborg included a surprisingly detailed test schedule that encompassed a 5-kiloton underground shot for seismic research (not dissimilar to those tests proposed by his predecessor, John McCone, in the first year of the moratorium); proof tests of both the Polaris missile and the Davy Crockett rocket; and a developmental test of a nuclear shell for 155mm artillery.[15] The first of these tests, Seaborg stressed, could not be detonated earlier than ten weeks from the date of authorization, a point that Komer had also made in the meeting of April.[16] This is a particularly important point when one considers the far more rapid resumption of testing achieved by the United States barely four months later.

[12] Subject: The Case for Resumption of Nuclear Tests, 28 April 1961; Reference Copy, Box 439; Robert W. Komer; Papers of President Kennedy, National Security Files; John F. Kennedy Library. For the proposed series of seismic research shots under Eisenhower, see Chapter Four of this thesis.
[13] Memorandum for the Record, Informal Meeting on Contingency Planning for the Resumption of Nuclear Testing, 27 April 1961; Reference Copy, Box 439; Robert W. Komer; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[14] Letter to John McCloy from Glenn Seaborg, 5 May 1961; Reference Copy, Box 299; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[15] Ibid.
[16] Ibid and Subject: The Case for Resumption of Nuclear Tests, 28 April 1961; Reference Copy, Box 439; Robert W. Komer; Papers of President Kennedy, National Security Files; John F. Kennedy Library.

Advocates of a resumption of testing could not, however, agree on the timeframe for that recommencement. Spurgeon Keeny, a member of the NSC whose counsel seemed to straddle both national security and science and technology, advised that the test ban negotiations be placed high on the agenda for the Vienna conference, but, if the Soviet response was unsatisfactory, the decision should be made to resume nuclear testing in December 1961.[17] This was obviously a longer period of time than the ten weeks expressed by Seaborg and Komer. Keeny wrote that

> Choice of this date would permit the design of a militarily useful test series of relatively short duration and would begin after the adjournment of the U.N. General Assembly. Preparation for the test series should begin after the decision on an orderly and *not* on a crash basis.[18]

Keeny was outlining two important points. The first of these was that there was a temptation to leap into a crash test program that would not achieve militarily useful ends. Despite his counsel, the United States would submit to that temptation and begin a crash test program once the Soviet Union recommenced testing in September. The second was that nuclear testing – specifically, its recommencement after a period of suspension – had assumed such a diplomatic and political character that Washington would be remiss to conduct such tests at the same time as the convening of the General Assembly of the United Nations. To do so would provide a forum for either the Soviet Union or the non-aligned countries to loudly voice their opposition to U.S. tests. Related to this last point was the realisation that the norm established under Truman, and eroded under Eisenhower, that nuclear testing was a

[17] Recommendation on Test Ban, 25 May 1961; Reference Copy, Box 439; Robert W. Komer; Papers of President Kennedy, National Security Files; John F. Kennedy Library. These recommendations are appended to a letter from Keeny to "Bob," presumably Robert McNamara, the secretary of defense.

[18] Ibid. Emphasis from the original. In the foreword to the addressee, Keeny states that "although I originally preferred an early July date, we have now delayed decision too long to hold a useful test series of short duration beginning reasonably in advance of U.N. GA."

rational and acceptable state action had been so entirely undermined by the moratorium that Washington now feared conducting such tests at the same time as the meeting of the United Nations. Many weeks later, Komer returned to the issue of the United Nations and, anticipating Kennedy's thoughts, imagined that the U.S. would resume testing "only after an all-out effort to validate our position, which means after the UNGA."[19] This was a different perception of the General Assembly than that expressed by Keeny, but a no less diplomatic one regarding the consequences of U.S. testing.

The internal shift toward test resumption within the Kennedy Administration was predicated upon the test ban negotiations, progressing poorly but still active at Geneva. The summit between Kennedy and Khrushchev in Vienna promised an opportunity to reignite the discussions. The two leaders met on 3 and 4 June, and Kennedy's weak performance in this meeting is still discussed by historians.[20] Dialogue regarding the test ban was eclipsed by Khrushchev's menacing comments on Berlin, and, in the absence of measurable progress, modest moves continued toward recommencing U.S. tests.

Throughout June and July, the debate regarding resumption deepened and its consequences became starker. Two dimensions to the decision to recommence testing were identified less than a fortnight after Vienna. The first was entirely political: that the United States should resume testing to assert its freedom of action. The second recalled the national security arguments arrayed against the moratorium in 1958: that

[19] Letter to Arthur [M. Schlesinger Jr.] from Robert W. Komer, 28 July 1961; Reference Copy, Box 439; Robert W. Komer; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[20] See Michael R. Beschloss, *The Crisis Years: Kennedy and Khrushchev, 1960-1963* (New York: Harper Collins, 1991). For the meeting as seen from Khrushchev's perspective, see chapter seventeen of William Taubman, *Khrushchev: The Man, His Era* (London: Simon & Schuster, 2003), 480-506.

the "balance of military advantage" favoured resumption because of the expected gains and because the Soviet Union might already be testing clandestinely.[21] This same memorandum, written to the under-secretary of state, expressed the "certainty" that the Soviet Union would resume testing once the United States did so. Just over three weeks after Vienna, the head of the USIA, Edward R. Murrow, described the test ban issue and the U.S. resumption of testing as "a key, conceivably *the* key, to our Cold War posture in the coming year."[22] On this he was largely correct, although Murrow could not have foreseen the course taken to U.S. resumption, nor the connection between test resumption and the intensifying Berlin crisis. Murrow also provided a very detailed public relations plan for the resumption of testing by the U.S. and the U.K., which placed an emphasis on "the irreducible minimum security requirements of the free world including the neutrals."[23]

It was within this context that, on 21 July, what was probably the single most important document for its bearing upon the test resumption debate was submitted to the NSC: the Report of the Ad Hoc Panel on Nuclear Testing, referred to as the Panofsky Report after its chairman, the balding and bespectacled Stanford physicist, Professor Wolfgang K. H. Panofsky.[24] The Panofsky Report considered the technical

[21] Subject: Program for Dealing with Adverse Public Reaction Abroad in Response to Renewed U.S. Nuclear Testing, 16 June 1961; Reference Copy, Box 299; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[22] Memorandum for Chester Bowles from Edward R. Murrow, 24 June 1961; Reference Copy, Box 299; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library. Emphasis from the original. Edward Murrow was the broadcast journalist who used his television program to confront Senator Joseph McCarthy at the height of McCarthyism.
[23] Ibid.
[24] The panel was composed of the luminaries of the U.S. scientific policy sphere, including Hans Bethe, Norris Bradbury (the director of the Los Alamos Laboratory), John S. Foster Jr. (director of Lawrence Livermore Laboratory), George Kistiakowsky

questions related to U.S. resumption – but made no comment on "very important non-technical or military issues" that the report acknowledged were equally significant.[25] It was a very cogent and articulate document, which concluded that no urgency existed to recommence nuclear testing and that the decision to resume was governed solely by non-technical considerations.[26] The Panofsky Report stated that there was no evidence for any Soviet clandestine testing since November 1958, and that any suspicious activity identified by intelligence was "equally compatible" with many activities unrelated to testing.[27] The panel considered the consequences of the resumption of underground testing and made a number of important points. First, weapons development tests would not be seriously impaired by restriction to underground testing, although that restriction would make some tests more difficult and expensive. Second, some weapons effects tests could not be carried out if testing was confined underground because of the importance of high-altitude and airburst shots to effects studies. The report noted that such high altitude tests were of interest to, but not critical to, the "AICBM problem." Third, in a circumstance where the United States conducted no nuclear tests but the Soviet Union undertook "very extensive clandestine testing," the Soviet Union's nuclear warhead capabilities could surpass those of the United States "in as little as three or four years."[28] This last point

(Eisenhower's science advisor after James Killian), Spurgeon Keeny (quoted above), and many other physicists.

[25] Report of the Ad Hoc Panel on Nuclear Testing July 21, 1961, page 1; Reference Copy, Box 301; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.

[26] Ibid, page 7.

[27] Ibid, page 2. This section of the report confirmed the argument made during the Eisenhower Administration that greater levels of clandestine activity – for example, decoupling – would correspondingly have a greater possibility of detection through "conventional intelligence."

[28] Ibid, pages 5, 10-11.

was undoubtedly alarming to its readers, but posed no immediate threat to U.S. nuclear superiority.

Also remarkable about the Panofsky Report was the explicit connection it drew between the type and objectives of nuclear tests, and the doctrine for the use of nuclear weapons. This was a connection that had been poorly made until the Panofsky Report. For example, improvements in yield-to-weight ratios achieved through weapons development tests affected, above all, mobile, high-yield weapons that were perfectly suited for a deterrent strategy. These weapons could survive a pre-emptive attack (through their mobility) and then destroy large, soft targets like cities (through their high yield). Test series that aimed at improvements in yield-to-weight ratio thus complemented a deterrent strategy. However, the Panofsky Report grimly if understatedly noted that development along these lines had reached something of a horizon because

> warheads of present yields delivered with the [precision] of existing systems would so completely over-kill the population and over-destroy the floor space of urban area targets by blast and fire, that further increases in yields would produce little additional damage.[29]

This was to say that the improvements in yield and weight of nuclear weapons, achieved through testing, had exceeded the requirements to destroy any individual target, and so there could be little practical progress to be further made in this field. The Soviet Union, however, certainly could not develop an advanced, mobile ballistic missile system such as that described above without additional tests.[30] Similarly, unlimited underground testing would probably reduce the capabilities of both the United States and Soviet Union to pursue a counterforce strategy, because increases in yield would be offset by increased mobility (which made a nuclear force that much

[29] Ibid, page 14.
[30] Ibid, page 16.

more difficult to destroy in a counterforce attack). Just as weapons tests led to improved yield-to-weight ratios and the diversification of the nuclear arsenal, continued improvements in weapons design would only increase the mobility and survivability of a second-strike force, which made its destruction in a counterforce attack all the more difficult.[31] In connecting the results of nuclear tests to the two strategies of deterrence and counterforce, the Panofsky Report was saying that the resumption of testing would contribute nothing new to the first and probably jeopardise American capabilities in the second.

Probably the most important contribution of the Panofsky Report to the resumption debate was that, by carefully rejecting the technical arguments for a resumption of testing, the report highlighted the fundamentally political character of the decision to resume testing. Summarising the "clear impressions" left by the report, Marc Raskin wrote to McGeorge Bundy days later and said that because there was "nothing critical" in the short-term that impaired the U.S. military posture by not testing, "the question of test resumption is one which must be considered almost totally in a political and psychological context rather than in terms of strategic technological considerations."[32] This is an important point, but one that could only be made before 30 August 1961. While the moratorium remained intact, so too did U.S. nuclear superiority, but the achievements of the Soviet test series in 1961 jeopardised this, and attention was again given to the "strategic technological considerations."

While elements of the NSC framed the question to resume testing in terms of a political rather than military decision, the Department of Defense and Joint Chiefs of

[31] Ibid, pages 17-20.
[32] Memorandum to McGeorge Bundy from Marc Raskin, 25 July 1961; Reference Copy, Box 299; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library. Raskin was special assistant to Bundy on the NSC.

Staff refused to abandon those strategic technological considerations. A note for General Maxwell Taylor signed by Kennedy questioned why the Joint Chiefs "took a very strong position against the [Panofsky] Report on testing…in view of the fact that the Chairman of the AEC [Seaborg] seems to find himself in general agreement in the findings and conclusions of the report."[33] In a meeting of the NSC the next day, Kennedy asked Panofsky himself to comment on the criticisms of his report from the JCS; Panofsky replied that he could not "make any intelligent comment because the criticisms of the Joint Chiefs were not spelled out."[34] By way of Taylor, who at this time occupied an awkward position interposed between the president and the Joint Chiefs, the JCS replied to the president's question and spelled out their criticisms one month after this meeting of the NSC. Their disagreement with the Panofsky Report was based entirely on the intelligence aspects of the report. The JCS believed there were "negligible risks involved" in clandestine testing and that, combined with the technical needs of the Soviet weapons program, there was a "strong possibility" that Moscow had clandestinely tested during the moratorium.[35] The CIA, by contrast, believed the political risks of exposure were a great deterrent to clandestine testing, and agreed with the Panofsky Report that there was no evidence either way that

[33] Memorandum for General Taylor from J.F.K., 7 August 1961; Reference Copy, Box 302A; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library. This memorandum was originally addressed to McGeorge Bundy, but his name was crossed out and "General Taylor" handwritten in its place. It was signed "J.F.K."
[34] Memorandum of Minutes of National Security Council Meeting – August 8, 1961; Reference Copy, Box 302A; Subjects; Papers of President Kennedy, National Security File; John F. Kennedy Library.
[35] Memorandum for the President from Maxwell D. Taylor, 8 September 1961; President's Weekend Reading, Box 2; Weekend Papers; John F. Kennedy Library.

Moscow had cheated during the moratorium.[36] Nonetheless, despite the divergence between the JCS and CIA on the available intelligence, both parties "agreed to the need for the United States to resume nuclear testing within a reasonable time."[37]

The most persuasive counter to the Panofsky Report came from General Taylor himself. Appearing to write to the president on his own behalf rather than that of the Joint Chiefs, Taylor took the greatest strength of the Panofsky Report – the connections it made between testing and strategy – and adapted it to his own argument. Taylor stressed the shortcomings of the Panofsky Report, which self-admittedly did not broach military issues. Taylor argued that, if the United States were to renounce a first strike and thus absorb a pre-emptive attack, it required a "secure retaliatory force, which is mobile and uses lightweight warheads"; further weapons development testing was required to develop this force.[38] Such a need would be made acute if it was concluded that the Soviet Union was going to beat or had beaten the United States to an anti-missile missile, because lighter warheads would permit decoys and multiple warheads to saturate and defeat a Soviet AICBM system. Moreover, sounding of the arguments from his book *The Uncertain Trumpet*, Taylor suggested that current U.S. tactical nuclear weapons were "generally too large and their aggregate effect too destructive" for use in friendly territory, and that it was of

[36] John McCone became director of the CIA in November; given his strong belief that the Soviet Union would cheat during a moratorium expressed while he was chairman of the AEC under Eisenhower, this author wonders what position the CIA would have taken had he been chairman just three months earlier.
[37] Ibid.
[38] Memorandum for the President from Maxwell D. Taylor, 7 August 1961; Reference Copy, Box 302A; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.

greater importance for the U.S. than the Soviet Union to develop smaller atomic weapons for tactical warfare.[39] Taylor concluded that

> a failure to resume testing seriously retards progress in developing both light strategic warheads and very small atomic weapons. Because of our military strategy, progress in both fields is worth more to us than to the USSR. This fact argues for a resumption of testing at once unless the most compelling of political arguments can be adduced against it.[40]

Here again, as with the Panofsky Report itself, Taylor was drawing attention to the political dimensions of the decision to resume testing, although from an entirely different perspective.

As this debate was carried out in July and August, far more practical preparations were being made for the recommencement of U.S. testing. In July, the AEC submitted details of desired tests and a rough test schedule that Robert Komer described as a "laundry list."[41] These tests were to be held in existing tunnels and holes – presumably at the Nevada Test Site (NTS) – and could begin barely a month after authorisation.[42] Only a week after the submission of the Panofsky Report, Robert McNamara, the secretary of defense, sent a long memorandum to John McCloy calling for preparations to resume nuclear weapons testing.[43] His letter requested weapons development tests to improve yield-to-weight ratios; weapons effects studies to explore results related to the AICBM; proof tests of Polaris, Minuteman and Davy

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[39] Ibid. *The Uncertain Trumpet* was arguably the basis of the Kennedy Administration's policy of flexible response. See Maxwell D. Taylor, *The Uncertain Trumpet* (New York: Harper, 1959).
[40] Ibid.
[41] AEC Memorandum on Nuclear Test Program for McGeorge Bundy from Robert Komer, 24 July 1961; Reference Copy, Box 299; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[42] Ibid.
[43] Letter to John McCloy from Robert S. McNamara, 28 July 1961; Reference Copy, Box 299; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.

Crockett weapons; and seismic research tests to explore decoupling. Meanwhile, correspondence between McGeorge Bundy and Glenn Seaborg in early August gives an indication of the preparations at the NTS. The readiness of the Nevada site was based largely on construction undertaken during Operations PLUMBBOB and HARDTACK Phase II in 1957 and 1958 and the abandoned preparations for an underground series in 1959-60.[44] Since that time, two tunnel complexes had been routinely cleaned, widened and lengthened. Seaborg recommended a number of possible actions to increase the readiness of the NTS to recommence testing that were ordered according to the risk of public disclosure that each action might court: for example, procurement of cables would involve a slight risk of public disclosure while tunnelling and placing of diagnostic, scientific instruments would pose an increased risk. Perhaps most importantly, at this point in August, the AEC could only conduct a few – “perhaps four” – test shots with “reasonable assurance that significant diagnostic information would be obtained.”[45] This comment from Seaborg harks back to the warnings of Spurgeon Keeny in May that any resumption of testing should be ordered and militarily useful – because the AEC was unprepared for anything more than a few scientifically measured, useful test shots. Indeed, as late as 30 August, the day on which the Soviet Union announced its intention to resume testing and the White House recalled ambassador Arthur Dean from Geneva, Seaborg wrote to Bundy that the only purpose of rapid testing was political rather than technical

[44] Readiness Position for Weapons Testing, appended to Letter to McGeorge Bundy from Glenn Seaborg, 10 August 1961; Reference Copy, Box 299; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[45] Ibid.

because "adequate diagnostic instrumentation could not be implaced [sic] and made operative in time."[46]

On 30 August 1961, the Soviet Union announced that it was resuming nuclear weapons tests, terminating the suspension that had existed for almost three years. According to Theodore Sorenson, Kennedy's speechwriter and close aide, the president's first reaction to the Soviet announcement was "unprintable"; according to McGeorge Bundy, of all the perceived Soviet provocations of 1961 and 1962, resumption of nuclear testing disappointed Kennedy the most.[47] The debate within the Kennedy Administration during 1961 regarding resumption was largely rendered irrelevant by the Soviet decision, which freed the United States from many of its concerns about how to resume its own testing. The response from the White House to the Soviet announcement was naturally critical, but it made the point that the purpose of Soviet intransigence in Geneva and over Berlin was to "abandon serious negotiations in order to free its hand to resume nuclear weapons testing."[48] Seaborg agrees, arguing that the Soviets were trying to "goad" the United States into breaking off the Geneva negotiations.[49] This argument is not a little disingenuous given that elements of the Kennedy Administration had contemplated and argued for U.S. test resumption long before the Soviet announcement was received.

[46] Letter from Glenn Seaborg to McGeorge Bundy, 30 August 1961; Reference Copy, Box 299; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[47] Theodore C. Sorenson, *Kennedy* (New York: Harper & Row, 1965), 619; Bundy, "The Presidency and the Peace," 359. Quoted in Seaborg, *Kennedy, Khrushchev, and the Test Ban*: 81, 84.
[48] Immediate Release, Office of the White House Press Secretary, 30 August 1961; Reference, Box 104; Subjects; Papers of President Kennedy, President's Office Files; John F. Kennedy Library.
[49] Seaborg, *Kennedy, Khrushchev, and the Test Ban*: 59.

Given the debate, muted as it was, that preceded the Soviet announcement of 30 August, the question arises whether Moscow had beaten Washington to the punch, and whether the United States would have resumed testing independent of the Soviet decision. This section of the thesis has attempted to show that internal discussion regarding test resumption was not a vacuum while the suspension was in effect, and that the United States could not have been totally surprised by Moscow's decision because it too had contemplated a similar path. But so long as Kennedy remained personally committed to test suspension – to British Prime Minister Harold Macmillan, Kennedy described himself as a "great anti-tester"[50] – and so long as the decision was freed from military and technical considerations and rendered a solely political one, it seems unlikely that the United States would have resumed testing had the Soviet Union not done so first. When the Soviet Union did recommence testing – rapidly and spectacularly – it produced a political response from the United States, and that response was a series of rushed nuclear tests of dubious technical value.

Underground Testing Resumes, Atmospheric Testing Considered

The Soviet Union followed its announcement of 30 August with its first nuclear test only two days later, which yielded approximately 150 kilotons of TNT equivalent.[51] The United States could contemplate a number of responses in the two days during which the Soviet announcement was one of intent, but the accomplished fact of the 1 September test limited those responses for both technical and political reasons. Technically, the United States feared that the Soviet Union might make

[50] Memorandum of Conversation Pertaining to Nuclear Matters, 21 December 1961; Reference Box 104; Subjects; Papers of President Kennedy, President's Office Files; John F. Kennedy Library.
[51] Seaborg, *Kennedy, Khrushchev, and the Test Ban*: 85.

advances in weapons technology, such as the AICBM; politically, the Soviet Union could not be allowed to test unilaterally and without challenge. The balance between these two aspects of the United States' response were skewed toward the political while Washington was caught by surprise, but, as U.S. testing resumed in the atmosphere and the Soviet Union tested its largest thermonuclear weapon, technical considerations came back into focus.

The Soviet resumption of nuclear testing was, by itself, a very important dimension of the Cold War and one not given deserved attention in the literature.[52] The decision to resume testing was closely connected in time and probably in motivation to the 1961 Berlin Crisis. Vice-President Lyndon Johnson certainly thought so during a meeting in that brief period between Moscow's announcement and its first test, and Khrushchev emphasised this reason on the same day during a meeting with members of the British parliament.[53] The idea that nuclear tests – specifically, their controversial resumption – could influence diplomatic proceedings lends them political significance; more to the point, nuclear testing offered an equally spectacular although marginally less bellicose method to affect decisions regarding Berlin than the blockade that Stalin had used in 1948. Of particular note was the

[52] For example, what is likely the best source on the Soviet perspective of the early Cold War, Vladislav Zubok and Constantine Pleshakov's *Inside the Kremlin's Cold War*, makes no mention of the Soviet resumption of testing except to discuss the 30 October 1961 test. These authors do, however, connect that specific test with the 1961 Berlin crisis. See Vladislav Zubok and Constantine Pleshakov, *Inside the Kremlin's Cold War: From Stalin to Khrushchev* (Harvard: Harvard University Press, 1996), 257-58.

[53] Seaborg, *Kennedy, Khrushchev, and the Test Ban*: 83-84, 87. On the matter of test resumption, William Taubman's otherwise-excellent biography of Khrushchev is notably silent – although it does mention that Andrei Sakharov, the mind behind the Soviet hydrogen bomb, had counselled Khrushchev against resuming testing because tests would "only favor [sic] the USA." Taubman, *Khrushchev: The Man, His Era*: 503.

scope and rapidity of the Soviet resumption. Moscow conducted at least three tests within a week of its announcement, all of a yield of tens of kilotons; by the first week of October, the U.S. had detected at least twenty-three airburst shots.[54] Edward Teller cautiously wrote that "the scale and success of this test series are impressive."[55] That scale and success made it obvious that extensive preparation for this series had been undertaken by the Soviet Union during the moratorium – Roswell Gilpatric, the deputy secretary of defense, estimated that these preparations had begun "about two years prior to resumption of testing" while Chester Holifield (D-CA), the chairman of the JCAE, estimated that "extensive clandestine preparations had been under way for many months."[56] Irrespective of their length, Soviet preparations clearly surpassed the maintenance and widening of the Nevada underground tunnels undertaken by the AEC, and realised the fears of test ban opponents in both Eisenhower and Kennedy Administrations.

The U.S. response to Soviet resumption was prompt, but rushed and impetuous. On 2 September, the day after the first Soviet test, Kennedy sent a private message to General Eisenhower advising him that "the U.S. is preparing to resume underground testing within two or three weeks. We are delaying public announcement

[54] Letter to President Kennedy from Roswell Gilpatric, 9 October 1961; Reference Copy, Box 299; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[55] Letter to President Kennedy from Edward Teller, 7 December 1961; Reference Copy, Box 299A; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[56] Ibid and Letter to President Kennedy from Chet Holifield, 24 December 1962; Reference Copy, Box 281A; Departments & Agencies; Papers of President Kennedy, National Security Files; John F. Kennedy Library. In a meeting between Kennedy and British Prime Minister Harold Macmillan later in December, Kennedy said that the Soviets had been preparing to test since February, that is, for six months. Memorandum of Conversation Pertaining to Nuclear Matters, 21 December 1961; Reference Box 104; Subjects; Papers of President Kennedy, President's Office Files; John F. Kennedy Library.

as long as possible in order to put the responsibility squarely on the [Soviet Union]."[57] That announcement came two weeks later on 15 September, which announced the first U.S. underground shot conducted that afternoon at Nevada. This statement from the White House proclaimed that the underground test – NOUGAT ANTLER – had "produced no fallout," although this was untrue and radioactivity was detected offsite.[58] By this time, the United States had detected ten Soviet tests, three of which were in the megaton range.[59] By contrast, ANTLER yielded either 2 or 6 kilotons.[60] The rush to oppose the Soviet Union's testing through nuclear tests of its own, combined with the vast discrepancy in the yields of their respective tests, led the United States toward a far more haphazard test series than either Glenn Seaborg or Spurgeon Keeny had counselled in months prior. As early as 30 August, Seaborg wrote to McGeorge Bundy that

> You also inquired how soon we would be able to commence [testing], and from the way you phrased your question, I had the impression that you were more or less hoping that that answer would be that we could commence rather soon – primarily for strategic and not necessarily for technical reasons.[61]

Seaborg explored this notion further many years later in his memoirs on the topic. He described a "sort of frenzy" that existed within the Kennedy Administration

[57] Message from President Kennedy to General Eisenhower, 2 September 1961; Reference Copy, Box 302; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[58] Immediate Release, Office of the White House Press Secretary, 15 September 1961; Reference Box 104; Subjects; Papers of President Kennedy, President's Office Files; John F. Kennedy Library. For more detail on this release of radioactivity and on Operation NOUGAT more generally, see Chapter Five.
[59] Ibid.
[60] There is some disagreement in the sources regarding the yield of ANTLER. The Department of Energy gives a figure of 2.6 kilotons while Seaborg recounts a figure of 6 kilotons. This author leans toward the prior figure, given that it was a test of a guided missile warhead. See also Chapter Five.
[61] Letter from Glenn Seaborg to McGeorge Bundy, 30 August 1961; Reference Copy, Box 299; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.

in September through which each test was seen as a political demonstration "for one ideology or its rival."[62] Thus, there was an impulse to "emulate" the Soviet Union and to emphasise "the political effects rather than the military preparedness aspects of testing."[63] This impulse was expressed on 5 September during a meeting between Kennedy, McGeorge Bundy, Seaborg, Gilpatric, General Taylor and others in which the discrepancy in yield of the first Soviet and U.S. tests was discussed. The first Soviet test yielded 150 kilotons, while the first U.S. test was expected to yield just 20 tons; Kennedy believed that this disparity would "invite much adverse comment" and requested a larger test, of 20 or more kilotons (although he settled for a test of a guided missile warhead that would yield around 2 kilotons).[64] The urgency to challenge the Soviet Union with more and larger tests made the problem of instrumentation at Nevada particularly acute, and diminished the technical and military data garnered from the NOUGAT series. For these reasons, Operation NOUGAT was a test series of profoundly political character that only tangentially responded to technical requirements, mostly in the form of proof tests.

While it was the rapidity and scale of the Soviet test series that drove the political response from the United States, those same characteristics, after reflection, focussed attention toward a comprehensive and measured test series. At the end of a long memorandum dated from the end of November, Seaborg articulated the fundamentally different approaches that the United States and Soviet Union had taken to the moratorium and what those meant for U.S. testing. He asserted that because the United States "was negotiating in good faith" at Geneva, its weapons design efforts

[62] Seaborg, *Kennedy, Khrushchev, and the Test Ban*: 87.
[63]Ibid.
[64] Ibid., 87-88. This warhead was probably tested in the ANTLER shot, which yielded 2.6 kilotons.

during the period of suspension was concentrated on "devices that could be stockpiled with adequate assurance without tests" – meaning weapons that did not depart radically from already proven concepts and designs.[65] By contrast, the "available evidence" – presumably, the high number and yield of Soviet atmospheric shots since 1 September – suggested that Moscow had anticipated future atmospheric testing and "orientated [its] efforts toward significant advances requiring such testing."[66] This line of thought, laced with suspicion as it was, articulated the fear that the Soviet Union would make important technological or theoretical progress in the field of nuclear weaponry that threatened the security of the United States, which it needed to match; specifically, through atmospheric testing.

The balance between the Kennedy Administration's technical and political perceptions of testing was conveyed in early November in a statement through which the president turned the nation's attention to atmospheric testing. The Soviet Union conducted its largest test (and what remains the highest-yield nuclear test ever conducted) on 30 October, almost exactly three years after the beginning of the moratorium. Kennedy publicly announced this test on 2 November, which, he noted, "exceeded 50 megatons."[67] Kennedy explored both political and technical dimensions when he said that the 30 October test "does enter into the Soviet campaign of fear, but these tests are, no doubt, of importance to Soviet leaders and scientists in developing

[65] Letter to the President from Glenn T. Seaborg, 29 November 1961; Reference Copy, Box 299A; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[66] Ibid.
[67] Statement by the President with Respect to Nuclear Testing, 2 November 1961; Reference Box 104; Subjects; Papers of President Kennedy, President's Office Files; John F. Kennedy Library. This Soviet test was of the so-called "Tsar Bomba" device which is variously described as yielding between 50 and 60 megatons, or roughly three to four times the yield of CASTLE BRAVO.

and improving nuclear weapons."[68] The president turned specifically to atmospheric testing and argued that the Soviet Union had undertaken atmospheric testing "for so-called psychological or political reasons," and that the United States was making preparations for a return to atmospheric tests "in case it becomes necessary to conduct them."[69]

Indeed, it was the progression of the Soviet test series and the growing awareness of its significance that convincingly argued the necessity for atmospheric tests. The question of whether the United States should also test in the atmosphere in effect replaced the question of whether the United States should resume testing, debated earlier in the year and made moot by the Soviet resumption. At about the same time that the United States came to appreciate the extent of Soviet preparation during the moratorium, Gilpatric argued that such were the technical accomplishments of the Soviet test series that the continued, unilateral U.S. restriction of atmospheric testing would "permit the USSR to obtain a technological gain of several years and obtain information which will be denied us without atmospheric testing."[70] Gilpatric was referring to effects studies most easily and effectively derived from atmospheric shots, especially those related to the vulnerability of ICBMs. He recognised that although a limited amount of data could be secured from low yield, underground tests, such tests could not provide all the data necessary "to satisfy defense requirements" and what data was obtained was done so "at a relatively

[68] Ibid.
[69] Ibid.
[70] Letter to President Kennedy from Roswell Gilpatric, 9 October 1961; Reference Copy, Box 299; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.

slow pace."[71] Gilpatric argued for atmospheric tests to supplement the ongoing underground shots because

> Intensifying our test activities is mandatory if we are to get the maximum technical data as quickly as possible. This will enable the United States to minimize [sic] the advantages being gained by the USSR in weapon and effects technology during their current tests.[72]

Seaborg wrote to the president at least three times in October to argue for atmospheric testing. He requested low yield atmospheric shots at Nevada and a "3-months' readiness posture" for high yield atmospheric shots at Eniwetok.[73] He observed the advantages of using tethered balloons for atmospheric shots, which could accelerate the NOUGAT series by one or two months and the STORAX series by four of five months because shots could be fired much more rapidly "if not inhibited by the lengthy process of preparing underground sites."[74] Not only were they faster, but atmospheric tests were also cheaper to conduct than underground tests. But, perhaps most decisive of his arguments was that underground testing was not suitable for tests of some weapons systems, effects tests, or proof tests of some stockpile weapons.[75] Although Seaborg did not explicitly say so, this argument, taken in conjunction with Gilpatric's memorandum of the previous day, suggest that both

[71] Ibid.

[72] Ibid. Included in this letter was a detailed test schedule that involved proof tests of Polaris, Atlas and Asroc weapons along with electromagnetic effects tests – all of which were carried out in the NOUGAT, DOMINIC and STORAX test series.

[73] Letter to President Kennedy from Glenn T. Seaborg, 10 October 1961; Reference Copy, Box 299; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.

[74] Ibid. It does not seem that this recommendation was accepted, because all shots fired as part of NOUGAT and STORAX were detonated in underground shafts or tunnels with the exception of the SUNBEAM effects tests, which were fired on the surface or mounted on towers. "United States Nuclear Tests: July 1945 through September 1992," 16-31.

[75] Letter to the President from Glenn T. Seaborg, 19 October 1961; Reference Copy, Box 299; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.

the AEC and Department of Defense had the AICBM in mind when they pushed for atmospheric testing. Seaborg, moreover, spoke on behalf of the laboratory directors in recommending the resumption of testing in the atmosphere.[76]

Discursively, the problem of atmospheric testing had supplanted the wider question of test resumption, and it was not without its opponents. Carl Kaysen, the deputy special assistant for national security affairs, submitted two papers to Kennedy in January 1962 arguing eloquently against the recommencement of atmospheric testing. He quite accurately observed that "while nuclear tests are not the most critical element in our strategic posture, they are the most highly visible and emotionally charged aspect of the arms race."[77] Here Kaysen was touching on the symbolic and political function of nuclear testing since the moratorium. But he warned that atmospheric testing would provoke a Soviet response, and that a series of atmospheric tests would not satisfactorily answer the questions to which they were directed and "must be viewed not as a self-contained series of tests but as the first step in what will be a continuing and expanding program of testing in the atmosphere."[78] The spiralling momentum toward further and further testing, experienced and curbed by Eisenhower, loomed again, and Kaysen feared that "the next opportunity for a pause will not arise till we and the [Soviet Union] have each completed at least two test series, a period of three or four years."[79] In a technical sense, Kaysen seconded Jerome Weisner, the president's science advisor, in saying that prospective technological losses from a continued suspension on atmospheric tests could be

[76] Ibid.
[77] Memorandum for the President from Carl Kaysen, 15 January 1962; Reference Box 104; Subjects; Papers of President Kennedy, President's Office Files; John F. Kennedy Library.
[78] Ibid.
[79] Ibid.

compensated through “more extensive exploitation” of underground and outer space testing.[80] Kaysen rejected the technical benefits of atmospheric testing by instead indicating, presciently it turned out, that anticipated weapons effects related to radar blackout (realised in the FISHBOWL tests) would only serve to show “how much less good” the AICBM was likely to be, because these effects could potentially limit the usefulness of ballistic missile interception.[81] Marc Raskin also articulated arguments against atmospheric resumption, although he framed his opinion in terms of both soft and hard power. He submitted to McGeorge Bundy that the United States could “reclaim” its moral and political leadership by not resuming tests in the atmosphere and that this would contrast with the tarnished reputations of the Soviet Union, United Kingdom and France.[82] More interestingly, Raskin argued that the U.S. return to atmospheric testing would indicate a precarious military balance between Washington and Moscow, because “one series of tests by the [Soviet Union] was enough to put the United States in jeopardy and in panic of its security.”[83] This is a persuasive line of thought, and one that perfectly articulates Sagan’s security model, but one that does not seem to have been developed by other actors within the Kennedy Administration. Finally, as if to balance these hard and soft arguments, Raskin suggested that the successful development of either the AICBM or the penetration of a Soviet defense system (the goals of atmospheric testing) would only affect the escalation and

[80] Memorandum for the President from Carl Kaysen, 5 January 1962; Reference Copy, Box 299A; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[81] Ibid. Moreover, Kaysen wrote, effects related to penetration and reduction in vulnerability of warheads could be determined from underground tests.
[82] Raskin was referring to the effect of Soviet test resumption and British and French colonial struggles on their global standing. Memorandum for Mr. Bundy from Marcus G. Raskin, 20 December 1961; Reference Copy, Box 299A; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[83] Ibid.

acceleration of the arms race.[84] How Kennedy received these arguments is unknown, but Robert Komer wrote a direct reply to Kaysen's memorandum that implied that any argument against atmospheric testing was overshadowed by the political arguments for atmospheric testing:

> At a time of crisis over Berlin and [south-east Asia]…it may be terribly important to utilize [sic] to the optimum the political deterrent value of any nuclear posture. Thus, even if further atmospheric testing will not produce major military gains, *I see political arguments for test resumption*.[85]

Testing, in this case in the atmosphere, for the sake of applying diplomatic pressure to the Soviet Union was precisely the same motivation the United States credited to the resumption of Soviet testing in September, and it appeared, at least to Komer, to be an especially important reason for doing so.

Kennedy himself was divided on atmospheric testing by his instinctive opposition to testing and by the counsel of his advisors. At the end of 1961, McGeorge Bundy surveyed the positions of the most senior advisors: vice-president Lyndon Johnson, Dean Rusk, Robert McNamara, John McCone (now director of central intelligence), Glenn Seaborg, Harold Brown and himself. "I regret to say," Bundy wrote to Kennedy, "that every one of these men, except yourself, favors atmospheric testing."[86] Seaborg's memoirs describe an ambivalent president during December 1961 and January 1962: "while I did not in general find Kennedy to be an

[84] Ibid.

[85] Emphasis is my own. Komer also paradoxically argued that a continued nuclear arms race might be the most effective manner to convince the Soviet Union "to think seriously about arms control." Memorandum for Carl Kaysen from Robert W. Komer, 18 January 1962; Reference Copy, Box 299A; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.

[86] Perhaps unsurprisingly, Bundy believed that "every one of these men" would support whatever decision Kennedy made – except John McCone. Memorandum to the President from McGeorge Bundy, 30 December 1961; Reference Copy, Box 299A; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.

indecisive man, he did vacillate on issues related to nuclear testing."[87] Kennedy had as company the American people, who, surveys showed, were deeply divided on the issue. At the end of November, a Gallup Poll revealed that 44% of respondents favoured the resumption of U.S. atmospheric testing, while 45% opposed it.[88] Theodore Sorensen noted that these figures made a national consensus behind a presidential decision more difficult, although he did point out that Kennedy's "reservoir of goodwill" was higher than that "which enabled Eisenhower to withstand similar pressures from the same people who wanted him to resume while the Geneva talks were in progress."[89]

There was, however, a practical obstruction to the resumption of atmospheric testing. High yield shots had always been conducted at the Pacific Proving Ground and plans submitted by the AEC and Department of Defense for an atmospheric test series called for the use of the Pacific islands. As Seaborg wrote to Kennedy, Johnston Island and Eniwetok Atoll were the "logical choices" because of Johnston Island's missile launching facilities and Eniwetok's existing test installations.[90] However, Eniwetok Atoll was part of the Trust Territory administered by the United States "subject to the supervision" of the United Nations after it was captured from Japan in the Second World War, and the State Department objected to its use in

[87] Seaborg, *Kennedy, Khrushchev, and the Test Ban*: 124.
[88] Oddly, despite the Soviet tests, the opposition was almost twice that of a survey using the same question in July. Memorandum for the President from Theodore C. Sorenson, 25 January 1962; Reference Copy, Box 299A; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[89] Ibid.
[90] Letter to President Kennedy from Glenn T. Seaborg, 30 October 1961; Reference Copy, Box 299; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.

atmospheric tests because of inherent opposition from the United Nations.[91] Dean Rusk feared that

> We are especially vulnerable to charges that by conducting tests in the Trust Territory we avoid exposing our own continental inhabitants to the dangers involved in proximity to atomic blasts by exposing our [Marshallese] wards in the Trust Territory to those same dangers. Such an argument is strengthened by the fact that the people of Rongelap have already suffered some injury as a result of their proximity to an atomic blast in the past [CASTLE BRAVO].[92]

The solution to this problem was to use the British possession of Christmas Island in conjunction with Johnston Island. The AEC identified the advantages of Christmas Island over other potential locations: foremost, it was not part of a U.N. trusteeship; it was located far from inhabited areas; basic facilities including an airstrip already existed; the island was relatively large; and it possessed a good harbour.[93] The use of Christmas Island was secured through a series of diplomatic exchanges from November 1961 through January 1962, which reached a crescendo with the Bermuda Summit of 21 and 22 December 1961 – the same meeting in which Kennedy described himself as a "great anti-tester."[94] Christmas Island was eventually

[91] Ibid and Letter to Glenn Seaborg from Dean Rusk, 29 October 1961; Reference Copy, Box 302; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library. The State Department anticipated that the U.N. would become a forum for "various groups of inhabitants" of the Trust Territory to object to U.S. tests. This was an entirely understandable position given the effect of CASTLE BRAVO, for example, on the native Marshallese. See Chapter Three.
[92] Letter to Glenn Seaborg from Dean Rusk, 29 October 1961; Reference Copy, Box 302; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[93] Commission Position on Christmas Island, 10 December 1962; Reference Copy, Box 300; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[94] Memorandum of Conversation Pertaining to Nuclear Matters, 21 December 1961 and Memorandum of Conversation Pertaining to Nuclear Matters, 22 December 1961; both in Reference Box 104; Subjects; Papers of President Kennedy, President's Office Files; John F. Kennedy Library. For an excellent account of the negotiations to secure the use of Christmas Island for U.S. nuclear testing, including the discussion at

used for all the shots of the Operation DOMINIC series with the exception of the high-altitude shots of FISHBOWL, which were fired above Johnston Island.

After an unassertive, internal debate about recommencing nuclear testing by itself, the United States resumed underground tests on 15 September 1961. This underground series, Operation NOUGAT, was almost entirely a political response to Soviet resumption and achieved little in a technical sense beyond proof tests of stockpiled warheads. This was because the NTS was unprepared for a measured test series and lacked the diagnostic equipment to record militarily and scientifically important information, and the urgency to resume precluded the installation of that equipment. NOUGAT was rushed and haphazard as a result of a political decision to oppose Soviet testing. The political dimension to test resumption came to be appreciated by members of the NSC, particularly Robert Komer, as a means to apply diplomatic pressure to the Soviet Union over issues such as Berlin, and this appreciation encouraged the extension of U.S. testing into the atmosphere. At the same time, the United States became aware, or perhaps fearful, that the extensive Soviet test series presaged important technological or theoretical developments, particularly in the field of the AICBM, and this awareness in turn compelled U.S. atmospheric testing to match. The political character of U.S. resumption speaks to the underlying threat that the Soviet 1961 series posed to the American nuclear lead, because almost without debate it was concluded that the Soviet series must be matched. As the most visible example of this conclusion, NOUGAT proved the old adage that half of something is better than all of nothing. But the return to nuclear testing after almost three years of suspension brought with it all the momentum for more and more tests that was seen under Eisenhower, a momentum that Kennedy

Bermuda, see Seaborg, *Kennedy, Khrushchev, and the Test Ban*: 117-35. Seaborg attended the Bermuda summit.

weighed in late 1961 and early 1962. After overcoming the obstacle posed by Eniwetok Atoll and Christmas Island, the United States detonated its first atmospheric test on 25 April 1962. Thus began Operation DOMINIC, and I turn next to the balance between U.S. and Soviet nuclear testing achieved through their test series of 1961-1963.

The Balance Between U.S. and Soviet Testing

The very different approaches taken by Washington and Moscow to the test moratorium and to test resumption – for example, the extensive preparations made by the Soviet Union to test and the ambivalent U.S. return to atmospheric testing – led to dissimilar test series between 1961 and 1963. As these were the final atmospheric series conducted by each nation, a circumstance preserved by international agreement rather than voluntary moratorium, the respective positions of each testing program was of special significance. Unlike 1958, where the United States had enjoyed a relative advantage in nuclear technology, the comparative positions of the U.S. and Soviet test programs were less clear in 1963, and, as a result of their dissimilar test series, the United States and Soviet Union stood in asymmetric positions in three areas: yield, medium of testing, and effects data.

The clearest divergence between U.S. and Soviet nuclear technology was in yield. This difference was apparent by the end of 1961 and remained the case by 1963. Kennedy and Macmillan discussed just this at the Bermuda Summit, and agreed that “in light-weight bombs, one half to one megaton, the United States is clearly ahead. In the three [to] four megaton range, the two countries are about equal, and the

Soviet Union has the advantage in the range from 25-100 megatons."[95] The Joint Chiefs of Staff reached the same conclusion almost two years later, despite the intervening test series. The JCS indicated that the Soviet Union was ahead of the United States in high yield – "tens of megatons" – technology in addition to weapons effects related to very high yield devices, but "lags somewhat behind" the U.S. at low yields.[96] This advantage was accrued through high yield atmospheric shots between 1961 and 1963: the Soviet Union conducted thirty-two tests of devices above one megaton during this time, a figure three and a half times greater than similar U.S. tests during that time and three more devices than the U.S. had tested since 1952.[97] As Kennedy had hinted at in his announcement of the Soviet test of 30 October (mentioned above), very high yield weapons served a military as well as a political-psychological purpose, as they were able to inflict damage to a target before interception by "presently conceived anti-ICBM systems."[98]

The Soviet lead in the field of very high yield weapons, a field not explored by the United States except accidentally, was demonstrated to the world through the 30 October 1961 test. The exact yield of this Soviet test remains unclear, although it was certainly so bewilderingly high a yield as to escape easy description. Many sources

[95] Memorandum of Conversation Pertaining to Nuclear Matters, 21 December 1961; Reference Box 104; Subjects; Papers of President Kennedy, President's Office Files; John F. Kennedy Library.

[96] Statement of the Position of the Joint Chiefs of Staff on the Three-Environment Nuclear Test Ban Treaty, 14 August 1963; Reference Copy, Box 266; Departments & Agencies; Papers of President Kennedy, National Security Files; John F. Kennedy Library.

[97] Military Implications of U.S. and Soviet Nuclear Testing, Report by the Twining Committee, 4 March 1963, page 2; Reference Copy, Box 302A; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.

[98] Technical Military Implications of Weapons Development and Weapons Effects Programs, 10 June 1963, page 37; Reference Copy, Box 376; Carl Kaysen; Papers of President Kennedy, National Security Files; John F. Kennedy Library. This idea will be further explored later in the chapter.

within the Kennedy Administration – including the normally opposed Bethe and Teller – attribute a yield of 60 megatons to the test, while post-Cold War sources instead credit 50 megatons.[99] Either figure greatly eclipsed the CASTLE BRAVO test of 1954, the highest yield test conducted by the United States, which yielded 15 megatons. Hans Bethe discussed this Soviet device and the general state of nuclear weapons development in a public lecture at Cornell University in January 1962. He explained to his audience that the device tested on 30 October was designed to yield a staggering "100 megatons or slightly more."[100] As designed, the fusion fuel of the device was surrounded with a tamper of fissionable uranium, but this was instead replaced in the test by a jacket of neutron-reflecting lead that "gave only a few megatons of fission."[101] Bethe was reprimanded by the AEC for sharing this detailed information in a public lecture.[102]

[99] Cornell University Lecture delivered by Hans Bethe, 5 January 1962; Reference Copy, Box 376; Carl Kaysen; Papers of President Kennedy, National Security Files; John F. Kennedy Library. Letter to President Kennedy from Edward Teller, 7 December 1961; Reference Copy, Box 299A; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library. Post-Cold War sources include Norris, "Soviet Nuclear Testing, August 29, 1949 - October 24, 1990."; Yuri N. Smirnov, "Three Interesting Episodes in the Soviet Nuclear Program," in *Monitoring a Comprehensive Test Ban Treaty*, ed. Eystein S. Husebye and Anton M. Dainty (Springer Netherlands, 1996); Victor Adamsky, and Yuri Smirnov, "Moscow's Biggest Bomb: The 50-Megaton Test of October 1961 " *Cold War International History Project Bulletin* 4(1994). Smirnov argues that the test was purely political, but as I shall explore below, very high yield weapons served a military purpose.

[100] Cornell University Lecture delivered by Hans Bethe, 5 January 1962; Reference Copy, Box 376; Carl Kaysen; Papers of President Kennedy, National Security Files; John F. Kennedy Library.

[101] Ibid.

[102] Bethe, along with the public sources he used, was reported to the Federal Bureau of Investigation because of his unauthorized disclosure of classified material. After months of investigation, Bethe was verbally reprimanded by Seaborg. Memorandum for Carl Kaysen from Spurgeon Keeny, Jr., 18 January 1962; Letter to President Kennedy from Glenn T. Seaborg, 11 June 1962; and Letter to President Kennedy

Along with the different emphases each power placed on the yield of its tests, the United States and Soviet Union differed also in the medium in which those tests were conducted. The Soviet Union resumed atmospheric testing immediately, while the United States recommenced testing underground and only after many months moved to atmospheric shots. Although this was an awkward decision in a political sense – for example, see Kennedy's concern with the unfavourable comparison of yield of U.S. and Soviet tests – there was a long-term technical advantage. The United States had more experience with underground testing than the Soviet Union, and was as a result "far ahead" in its "capacity to test underground."[103] It was, after all, the United States through Operations PLUMBBOB and HARDTACK II that had determined the difficulties of detection posed by underground tests, and, of the three test series conducted by the United States during the period of resumption, two were underground series. By contrast, the Soviet Union had little to no experience with underground testing. To develop the infrastructure and facilities for underground tests would be both "costly and time-consuming," and such an effort might slow Moscow's progress by "the equivalent of a year."[104] The United States, meanwhile, had between February and May 1963 developed the ability to conduct simultaneous underground detonations – an important technique for defeating or confusing the detection of underground tests.[105] Indeed, the Soviet inexperience with underground nuclear testing, particularly compared to the United States' capability to obfuscate its own

from Carl Kaysen, 4 July 1962; all in Reference Copy, Box 376; Carl Kaysen; Papers of President Kennedy, National Security Files; John F. Kennedy Library.

[103] Memorandum for President Kennedy from Carl Kaysen, 15 January 1962; Reference Box 104; Subjects; Papers of President Kennedy, President's Office Files; John F. Kennedy Library.

[104] Ibid.

[105] See the section on Operation STORAX in Chapter Five.

underground shots, in essence deflated the fears of test ban opponents who had imagined the Soviet Union capable of extensive, clandestine, underground test series.

A further although less distinct divergence between the U.S. and Soviet test series was in the area of weapons effects. The Twining Committee Report – an alarming document authored by a committee that included Edward Teller and was chaired by the former chairman of the JCS, General Nathan Twining – explored the consequences of U.S. and Soviet effects tests.[106] Both nations had conducted high altitude effects tests related to the phenomena of radar blackout and radio absorption, and the U.S. had obtained "considerable information on this effect."[107] But the tests that had generated this information were all nighttime shots, and evidence from the HARDTACK TEAK shot of 1958 had suggested that the effects were more pronounced in daylight. This was because of the phenomenon of photodetachment, presumably caused by the interaction of the sun's electromagnetism with the products of the bomb debris, and "the blackout from a daytime shot – both radar and communications – might thus be far greater than for a corresponding nighttime event."[108] Soviet tests in this field were all conducted during daytime, and, to the members of the Twining Committee, it seemed that the Soviet Union might have recorded more data and/or possessed a better understanding of the phenomena of blackout and communications disruption than the United States.[109] But it was not

[106] Other members of the committee included Stanislaw Ulam, a physicist as much, if not more so, the father of the hydrogen bomb as Teller; General James Doolittle, who had commanded the eponymous Doolittle Raid over Tokyo during the Second World War; along with a number of scientists and former air force commanders.
[107] Military Implications of U.S. and Soviet Nuclear Testing, Report by the Twining Committee, 4 March 1963, page 17; Reference Copy, Box 302A; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[108] Ibid.
[109] Ibid.

mentioned that the Soviet Union might instead be entirely unaware of the lesser effect of nighttime shots, as a direct result of its daytime tests.

The balance between U.S. and Soviet tests between 1961 and 1963 was important for the acceptance of a test ban treaty. Of the three asymmetries identified above, Washington and Moscow each enjoyed one advantage while the third remained uncertain. The implication of the Soviet lead in very high yield weapons was that the U.S. could not realistically develop them if it committed to a test ban. Tests of such weapons were only possible through atmospheric testing, and their enormous yield made detection easy, meaning that it would be essentially impossible for a state to conduct clandestine tests related to very high yield weapons. The Soviet Union had already tested and developed weapons in this field while the United States had not. But the institution that, given the debate that preceded the moratorium, might have posed the greatest objection to this U.S. disadvantage – the JCS – was surprisingly sanguine about very high yield weapons. By mid-1963, the JCS had concluded that U.S. disadvantage in this field "should not be regarded as a major problem" since very high yield weapons "do not have major strategic significance."[110] The JCS did not "regard as important" the attainment of weapons to rival the Soviet 30 October test, and felt that "the types and numbers of megaton yield weapons available to us now or in the future could give [the United States] an adequate capability in the high-yield range."[111] Similarly, the United States held a clear

[110] Memorandum for McGeorge Bundy, Subject: The Positions of Admiral Anderson and General LeMay on a Limited Test Ban, 16 July 1963; Reference Copy, Box 266; Department & Agencies; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[111] Statement of the Position of the Joint Chiefs of Staff on the Three-Environment Nuclear Test Ban Treaty, 14 August 1963; Reference Copy, Box 266; Department & Agencies; Papers of President Kennedy, National Security Files; John F. Kennedy Library.

advantage in the only medium of testing permitted under the LTBT – underground – and its experience with the obfuscatory technique of simultaneous underground detonation gave Washington a good reason to commit to the treaty.

Important, determinist questions emerge from the balance of Soviet and U.S. testing between 1961 and 1963. Until the moratorium, both powers' nuclear test programs were largely linear, the Soviet following the American, with minor divergences such as the scientific choices between the Alarm Clock, Sloika and radiation implosion designs for the hydrogen bomb.[112] As a result of the Soviet preparations during the moratorium, it conducted an extensive and effective test series in 1961 that the U.S. was unable to immediately match, and, by 1963, subtle but observable differences emerged in the emphases of their test series. These imbalances were mainly of yield and medium, and can be explained as political and scientific choices. But these differences were only of emphasis: by this stage of the Cold War, both the United States and the Soviet Union had progressed through fission bombs to boosted fission, then fusion, then toward weapons effects studies and AICBM defences. To what extent this linear evolution was a result of espionage, or imitation, or a determinist limitation imposed by nuclear science remains unclear. Lacking answers to this question, I shall discuss the final objective of that linear technological progression: the anti-ICBM.

The AICBM

Of all the technical arguments for atmospheric nuclear testing, the development of, and the vulnerability of intercontinental missiles to, an anti

[112] For a history of the design processes on the path to the hydrogen bomb, see Rhodes, *Dark Sun: The Making of the Hydrogen Bomb*; Holloway, *Stalin and the Bomb: The Soviet Union and Atomic Energy 1939-1956*.

intercontinental ballistic missile (AICBM) system were the most vocal and compelling. The AICBM cast a shadow over the debate about nuclear testing of shorter length but equal significance to that cast by the thermonuclear weapon during the hydrogen bomb debate within the Truman Administration in the winter of 1949-1950. The attraction of the AICBM was not limited to the Kennedy Administration: as discussed in Chapter Four, the AICBM was held as the darling of those opposed to the test moratorium during the Eisenhower Administration, especially the JCS and the AEC. There was an understated value to the resumption of U.S. atmospheric nuclear testing in disproving the most optimistic assessments of the AICBM, which in the absence of such testing might forever have remained a promising potential on the technological horizon. But more generally, the AICBM holds significance because it represented the ultimate expression of the U.S. nuclear posture and technology at the time that atmospheric testing was abandoned, and was arguably the culmination of the eighteen tests series conducted by the United States between 1945 and 1963.

Interest in the AICBM did not wane during the years of the moratorium, but supporters of that suspension had demonstrated that the fundamental problems of the AICBM were related to its delivery rather than its warhead. These problems included the engineering of, and electronic and guidance systems for, the rocket or missile that would deliver the warhead. It is unclear whether these problems were completely solved during the moratorium, but discussion regarding the AICBM and the lobbying of scientists such as Edward Teller suggests that they were overcome at least so far as to conduct relevant atmospheric effects tests in 1962. These tests were of paramount importance for the subsequent development of the AICBM. Teller wrote to Kennedy on 7 December 1961 – and this author wonders if Teller deliberately chose the twentieth anniversary of the attack on Pearl Harbor to underline his arguments for military preparedness – and provided a clear description of the state of the AICBM at that time. Information pertinent to an AICBM defense and the penetration of a Soviet AICBM system, Teller argued, "can be obtained in most cases only by atmospheric testing" because weapons of megaton-yield and missile defense experiments could not be conducted underground.[113] Teller was probably referring to the need to gather weapons effects data in the medium that the AICBM would be used – that is, at various altitudes of the atmosphere – and the excessive difficulty of containing megaton-yield detonations underground.

But if the technical dilemmas had been overcome to the point of continued testing, the period of reflection offered by the moratorium had posed new problems to the AICBM. Hans Bethe best qualified this new problem in his controversial speech at the beginning of 1962. On the topic of the AICBM, Bethe began by implying that the problems of guidance and delivery had been largely solved since 1958 because it was "not very difficult to design a defensive missile which will come close enough to an ICBM to destroy it by means of an atomic explosion."[114] But he identified a wholly new problem: an attacker could send decoys along with its missiles, or it could saturate a defender's radar with many missiles simultaneously, all of which would act to limit the effectiveness of an AICBM.[115] Bethe made no mention in this public lecture of the effect of radar blackout achieved by high-altitude nuclear explosions – observed in the HARDTACK and ARGUS tests of 1958 – which an attacker could

[113] Letter to President Kennedy from Edward Teller, 7 December 1961; Reference Copy, Box 299A; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[114] Cornell University Lecture, January 5, 1962, Delivered by Hans A. Bethe; Reference Copy, Box 376; Carl Kaysen; Papers of President Kennedy, John F. Kennedy Library.
[115] Ibid. Because of these problems, Bethe concluded that the AICBM was "virtually hopeless."

use as a precursor to a saturation of missiles and decoys in order to penetrate an AICBM system. Teller discussed this problem in more detail. Decoys could be discerned from an incoming warhead only at relatively low altitudes, where the thicker atmosphere would slow down "the numerous light decoys that can be cheaply delivered together with the nuclear explosive," but warheads and decoys could not be discriminated above an altitude of thirty or forty kilometres.[116] From this point, the practical threat of very high yield Soviet tests (such as that of 30 October 1961) emerged: these weapons could cause "very extensive damage" even when detonated above the effective ceiling of an AICBM system.[117]

Operation DOMINIC responded to the need for effects data and "greatly advanced" U.S. understanding of weapons effects related to the AICBM. Experiments were conducted to reduce "uncertainties and vulnerabilities," reveal new physical phenomena, refine information regarding blackouts and penetration aids, and optimise warheads for the anti-ballistic missile role.[118] Of particular interest were blackout effects, as explored in the FISHBOWL tests. It was concluded that multiple radars with many lines-of-sight were required to effectively defend a target because of radar blackout, an exceptionally expensive proposal that was made more difficult by self-blackout, where a defensive AICBM detonation would disrupt the defender's own radar. As explored in Chapter Four, radar blackout was caused by both the delayed fission products of the warhead as well as the ionization of the surrounding air by the nuclear fireball. Self-blackout could be reduced through development of a clean

[116] Letter to President Kennedy from Edward Teller, 7 December 1961; Reference Copy, Box 299A; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[117] Ibid.
[118] Technical Military Implications of Weapons Developments and Weapons Effects Programs, 10 June 1963, page 2; Reference Copy, Box 376; Carl Kaysen; Papers of President Kennedy, National Security Files; John F. Kennedy Library.

warhead, an all-fusion device that would do away with the fissionable material that contributed to radar disruption. A related problem was the vulnerability of AICBM warheads to the nearby detonation of other interceptor warheads – because it was "necessary to fire more than one defensive missile at each incoming dangerous object in order to insure a high enough probability of kill."[119] Multiple detonations of AICBM warheads made the challenge of radar blackout acute. Meanwhile, experiments in optimised warhead design generated interest in enhanced radiation weapons (ERWs): the so-called neutron bomb. ERWs generated much greater high-energy neutrons and prompt radiation than conventional nuclear weapons, and could be used tactically as an airburst to kill or incapacitate personnel. But for the purpose of an AICBM, ERWs had an increased probability to kill an incoming missile because the neutrons acted to induce fission within the fissionable material of an ICBM and so detonate the missile prematurely.[120] Tests in the DOMINIC series not only explored the capabilities of a U.S. AICBM, but also the vulnerability of U.S. missiles to a Soviet AICBM; while the Soviet Union conducted as part of its final test series in 1963 "several sophisticated high altitude experiments" that were probably experiments with radar blackout effects.[121]

Despite the data garnered from DOMINIC and FISHBOWL, the limitations imposed on the AICBM were ultimately as insurmountable in 1963 and they had been in 1958, although for very different reasons. There were two related dimensions to the failure of the AICBM. Firstly, interception was a problem "dominated" by the concerns of the reaction time of the system, its "traffic handling capacity," and its

[119] Ibid, 28.
[120] Ibid, 12.
[121] Ibid, 48.

ability to discriminate decoys from warheads.[122] These problems were exacerbated by weapons effects like electromagnetic pulse, radar blackout and radio disruption. The Twining Committee Report recognised this problem but understated its consequence, saying only that "if the [AICBM] system is faced with multiple warheads which must be attacked simultaneously, it may find it difficult to operate in an environment of multiple fireballs even though several radars are employed."[123] Secondly, the economic exchange between ICBM and AICBM did not favour the latter. It was far cheaper for an adversary to saturate an AICBM than it was to field a defensive system of sufficient complexity and ruggedness to defeat that attack. This problem was in turn exacerbated by the use of decoys and penetration aids, which, it seemed, would always remain technologically ahead of the defense.[124] Probably for these reasons, even the Joint Chiefs of Staff – the indomitable defenders of the AICBM in 1958 – had concluded by mid-1963 that "in the antiballistic missile field, development of the US system does not depend on atmospheric testing and hence this treaty [the Limited Test Ban Treaty] will not significantly influence any imbalance that may exist."[125] Moreover, it was probably the failure of the AICBM that diminished the Joint Chiefs'

[122] Ibid, 34.

[123] Military Implications of U.S. and Soviet Nuclear Testing, Report by the Twining Committee, 4 March 1963, page 16; Reference Copy, Box 302A; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.

[124] "The lead time for a change of penetration aids is perhaps half of the lead time to deploy a defensive system." Technical Military Implications of Weapons Developments and Weapons Effects Programs, 10 June 1963, page 34; Reference Copy, Box 376; Carl Kaysen; Papers of President Kennedy, National Security Files; John F. Kennedy Library and Report of the Ad Hoc Panel on Nuclear Testing July 21, 1961, page 4; Reference Copy, Box 301; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library. The Panofsky Report made its conclusions based solely on the Nike-Hercules interceptor system.

[125] Statement of Position of the Joint Chiefs of Staff on the Three-Environment Nuclear Test Ban Treaty, 14 August 1963; Reference Copy, Box 266; Departments & Agencies; Papers of President Kennedy, National Security Files; John F. Kennedy Library.

interest in very high yield weapons, because the chief advantage of those weapons was in their ability to defeat an AICBM defense.

The AICBM was a telling example of the influence of nuclear testing on weapons technology and nuclear thought, and so it was appropriate that it was testing that ultimately proved its inefficacy. The United States entered the moratorium knowing that the AICBM could not be further developed through tests, but once technical problems with its delivery system were overcome, tests conducted as part of Operation DOMINIC showed that the AICBM was very vulnerable to particular weapons effects, and no further amount of atmospheric testing was likely to change that. But the AICBM also spoke to a deeper desire – more dramatically expressed through the Strategic Defense Initiative of the Reagan era – that nuclear weapons might serve defensive purposes, or that there were technological defences against the spectre of nuclear catastrophe. Noble though this notion was, it was a deeply flawed one. Speculation about the AICBM in 1962 and 1963 paints a picture of an intense, dramatic and confused battle fought in the airspace of a nation between incoming nuclear missiles and defensive, anti-missile interceptors: a battle fought by multiple nuclear detonations at many altitudes, filling the sky with fireballs, mushroom clouds, radar blackouts, radio disruption, electromagnetic pulse effects – and fallout. In the case of the AICBM as it was in 1963, the remedy was only marginally less deadly than the poison.

The Limited Test Ban Treaty

In the aftermath of the Cuban Missile Crisis of October 1962, negotiations toward a test ban were reinvigorated and, following difficult talks in early 1963, the path emerged to the Limited Test Ban Treaty.[126] The LTBT realised at least in part the hopes of test ban advocates like Vannevar Bush, Thomas E. Murray, Adlai Stevenson, James Killian and George Kistiakowsky, and even presidents Eisenhower and Kennedy. It promised an international treaty to end atmospheric nuclear testing of far more durability than the moratorium that had lasted between October 1958 and October 1961, and neither the United States nor the Soviet Union have conducted a nuclear test in the atmosphere, underwater or outer space since 1963. This final section of the chapter shall briefly explore how the LTBT came to be accepted by the Kennedy Administration and what its restrictions meant for U.S. nuclear testing.

The LTBT was not a comprehensive agreement to ban all nuclear tests, although it was more effective than the voluntary moratorium achieved by Eisenhower. Testing in the atmosphere, in outer space, and underwater were prohibited by the treaty, which left underground tests exempt from its auspices. The problem of detection remained, and, despite many years of negotiation at Geneva, the United States and the Soviet Union could find no accord in how to solve it.[127] A limited treaty that exempted underground testing would be far less problematic to monitor because of the relative ease of detecting tests conducted in the atmosphere, outer space, and underground. Moreover, a limited treaty was more acceptable to the Soviet Union and to many of the internal actors in the U.S. government (not least of which were the JCS and especially the Senate, whose approval of any treaty was essential) because underground testing still offered the potential to continue nuclear weapons development, albeit in a constrained fashion. Twice the United States had

[126] For the best account of the negotiations for the LTBT, see parts four and five of the memoirs of the chairman of the AEC, Glenn Seaborg. Seaborg, *Kennedy, Khrushchev, and the Test Ban*: 159-282.
[127] See Chapter Four.

proposed what was essentially a limited test ban – firstly, in 1959, one of Eisenhower's final efforts to end nuclear testing; and, secondly, in 1961, following the Bermuda summit and the Soviet Union's sudden resumption of testing – but the concept only became acceptable to Moscow in the aftermath of the Cuban Missile Crisis. William Taubman describes a Khrushchev who only days after standing at the brink of nuclear war was "at last ready for the relationship Kennedy had offered at the Vienna summit."[128] But a test ban did not emerge immediately as the two countries pulled back from Cuba; in the words of Seaborg, "the high hopes that both President Kennedy and Premier Khrushchev seemed to have entertained that the world's brush with catastrophe might hasten a test ban agreement were, for the moment, not realized."[129] Those high hopes took almost a year to be fulfilled.

There were obvious consequences to the development of nuclear weapons from a ban on tests in the atmosphere and outer space. Most apparent was that an atmospheric test ban "would, for all practical purposes, eliminate for both sides the possibility of acquiring further effects data basic to penetration and [the AICBM]."[130] Although the AICBM had proved impractical and further refinement of the concept unlikely, it could not be ruled out, and it was almost certainly of comfort that neither power could develop a potentially destabilising technology. On the other hand, success of the AICBM was beholden to the "important details of design and cost," and, as in 1958, these details could be solved without atmospheric testing.[131] It is unclear which of these perspectives on the relationship between a test ban and the

[128] Taubman, *Khrushchev: The Man, His Era*: 583.
[129] Seaborg, *Kennedy, Khrushchev, and the Test Ban*: 185.
[130] Technical Military Implications of Weapons Developments and Weapons Effects Programs, 10 June 1963, page 48; Reference Copy, Box 376; Carl Kaysen; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[131] Ibid, 49.

development of the AICBM took precedence, but both acted to remove the AICBM as a reason for continued testing. Relatedly, the possible future of indefinite, unlimited nuclear testing promised "the most likely ultimate result" of technical parity between the United States and Soviet Union.[132] A test ban in 1963 preserved however temporarily the U.S. advantages in low yield devices and underground testing, leaving only the Soviet advantage of very high yield devices which was of no interest to the U.S. military. Indeed, the limitation imposed by the test ban promised only modest technological developments, which meant that parity between the two powers could be realised through total stockpiled warheads and their delivery systems. A particular strength of the LTBT was that, by restricting potential future technological developments, it in turn diminished the kind of threats to a nation's security that had driven the U.S. resumption of nuclear testing in 1961.

Opposition within the Kennedy Administration to the test ban was far less apparent than that mounted by the AEC, JCS and Department of Defense against the voluntary moratorium in 1958. For reasons previously explored, including the inefficiency of the AICBM and the subsequent disinterest in very high yield weapons, the principal arguments of the JCS against a test ban were removed. Although the Joint Chiefs considered the advantages of any limited test ban "in reality more political than military," these seemed to outweigh any military-technical requirements.[133] The JCS described these advantages as: a potential increase of "trust and confidence" if the Soviet Union abided by the treaty; the easing of global tensions; constraint upon the "further diffusion" of nuclear weapons technology;

[132] Ibid, 45.

[133] Memorandum for McGeorge Bundy, Subject: Military Advantages of a Nuclear Test Ban, 23 July 1963; Reference Copy, Box 266; Departments & Agencies; Papers of President Kennedy, National Security Files; John F. Kennedy Library.

increased tensions between the nuclear Soviet Union and non-nuclear People's Republic of China; reduced global fallout levels; reduction in defense costs; and a possible slowing of the arms race.[134] Nonetheless, the JCS affirmed the importance of continued underground testing "at a rate to insure continued progress in nuclear technology" – and it is difficult to imagine that the JCS would have supported a comprehensive test ban.[135] That Kennedy did not face the kind of domestic opposition to the LTBT that Eisenhower faced toward the moratorium was likely the confluence of several factors. Unlike the moratorium, the LTBT permitted that for which John McCone, fighting the rearguard as chairman of the AEC, had argued in the days leading up to the moratorium in October 1958: underground testing. Secondly, and less tangibly, the effect of the Cuban Missile Crisis (and, specifically, the effect of the DOMINIC CALAMITY shot on 27 October 1962) probably sobered opinions in both Washington and Moscow regarding nuclear testing. U.S. testing had begun politically, and the CALAMITY test had political effects upon an international crisis. Thirdly, Kennedy enjoyed far greater support from the AEC under Seaborg than Eisenhower had under Strauss and McCone. This agential reason should not be lost among the more structural factors that underpinned the LTBT.[136] Finally, the technological horizon was – for the first time in the history of U.S. nuclear testing – clear of potential developments. No hydrogen bomb loomed as it did in 1952, and the AICBM that had loomed in 1958 had been disproved by the set of tests conducted between 1961 and 1963. In the fields of science for which atmospheric testing were relevant,

[134] Ibid.
[135] Statement of Position of the Joint Chiefs of Staff on the Three-Environment Nuclear Test Ben treaty, 14 August 1963; Reference Copy, Box 266; Departments & Agencies; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[136] Benjamin Greene agrees. See Greene, *Eisenhower, Science Advice, and the Nuclear Test Ban Debate, 1945-1963*: 235.

that horizon had been reached, and only technical improvements to delivery systems possible without atmospheric tests remained, such as the multiple independent re-entry vehicle and mobile, land-based ICBMs.

Among the contentious technical statements that Hans Bethe submitted in his public lecture at Cornell University in January 1962 was his opinion that "nothing fundamental is likely to be changed by any amount of future nuclear testing."[137] Bethe was certainly not an entirely objective scientist, and he was publicly committed to the pursuit of a test ban. But in this he was probably, for the most part, correct. It is of course very difficult to prove the absence of something, as Bethe argued, but it is possible to say that the United States' nuclear arsenal was most secure in 1963 and that this alone was an excellent reason to commit to the LTBT. This security came through eighteen years of weapons development, weapons effects studies, safety tests, and proof shots that gave Washington confidence in its arsenal. In 1962 as in no other year before then was it possible for Bethe to say that nuclear testing promised nothing fundamentally new; this remained the case in 1963.

In a nationwide radio and television address at the end of July 1963, the president delivered an eloquent and intelligent summary of the LTBT. Kennedy described the successful conclusion of negotiations for the treaty as "a shaft of light cut into the darkness."[138] His defense of the treaty mirrored points made later by the JCS: it was a step toward reduced tensions and "broader areas of agreement"; it freed the world from the fear of radiation and fallout; it arrested the spread of nuclear

[137] Cornell University Lecture delivered by Hans Bethe, 5 January 1962; Reference Copy, Box 376; Carl Kaysen; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[138] Remarks of the President in Nationwide Radio-TV Address, 26 July 1963; Reference Box 46; Speech Files; Papers of President Kennedy, President's Office Files; John F. Kennedy Library.

weapons; and the treaty strengthened U.S. security by limiting the arms race.[139] But these were all first steps rather than final accomplishments, and Kennedy concluded expressively:

> My fellow Americans, let us take that first step. Let us, if we can, get back from the shadows of war and seek out the way of peace. And if that journey is one of a thousand miles, or even more, let history record that we, in this land, at this time, took the first step.[140]

Indeed, the same limitations that meant the LTBT could be widely accepted also made that first step appear a modest thing. As Kennedy himself noted, the LTBT did not reduce the stockpiles of the nuclear powers, it did not halt the production of nuclear weapons, and it would not prevent their use in conflict.[141] Seaborg agreed. In his memoirs on the test ban and its negotiation, he wrote that "I regard the failure to achieve a comprehensive test ban as a world tragedy of the first magnitude."[142] Although a comprehensive test ban would not be signed until the Berlin Wall and the Iron Curtain had fallen, the first step achieved in 1963 was a not insignificant thing.

On the morning of 24 September 1963, the United States Senate consented to the LTBT and, at 10:45am, President Kennedy was handed a card that read "Test ban vote 80-19."[143] One can imagine the president's reaction: thus ended eighteen years of U.S. atmospheric nuclear testing

Conclusion

During the thousand days of the presidency of John F. Kennedy, the United States moved from the test moratorium in 1961, to a period of extensive testing that

139 Ibid.
140 Ibid.
141 Ibid.
142 Seaborg, *Kennedy, Khrushchev, and the Test Ban*: 242.
143 Test ban vote, 24 September 1963; Reference Box 46; Speech Files; Papers of President Kennedy, President's Office Files; John F. Kennedy Library.

spanned probably the most challenging crisis of the Cold War in 1962, to the Limited Test Ban Treaty by the end of 1963. Although nuclear testing under Kennedy appeared – when considered within context of the test moratorium and the erosion of the norm of nuclear testing the moratorium achieved – an awkward, irrational epilogue, these test series were of profound importance to the achievement of the LTBT. Only through these tests, the way in which they clearly defined the end of the usefulness of atmospheric testing, disproved promising technologies, and rendered obsolete an ineffective and voluntary agreement, could the hopes of both Eisenhower and Kennedy be realised, however imperfectly.

The return to nuclear testing, which had been contemplated by Washington long before the Soviet Union abrogated the moratorium, was borne out of a perceived threat to U.S. security that was felt more acutely in 1961 than at any time under Truman or Eisenhower. Although the United States had considered recommencing testing independently, it was unlikely to have done so while scientists advised that there was little technical reason to do so and the president remained personally committed to not testing. But the preparations the Soviet Union had made to test during the moratorium allowed it to conduct an impressive test series in 1961 that the United States could not easily match, and this, it was feared, had narrowed the technological gap between the two powers. The political nature of the U.S. response – that the Soviet Union could not be allowed to test unilaterally, no matter how technically ineffective the rejoinder – carries the implication of this threat to security. Marc Raskin observed just this when he wrote at the end of 1961 that “one series of tests by the [Soviet Union] was enough to put the United States in jeopardy and in panic of its security."[144] But as Scott D. Sagan noted in defining the security model used in this chapter, it is difficult to explicitly connect this threat to individual decisions within the Kennedy Administration.

The United States' security was improved by the series of 1961 to 1963. This was achieved foremost in the proof tests of important weapons systems, especially the Polaris submarine-launched missile exploded as shot FRIGATE BIRD of Operation DOMINIC. Similarly, the FISHBOWL tests of DOMINIC, despite their many embarrassing failures, had given the United States experience in the launching of rockets and missiles with nuclear warheads, and effects studies from these shots had proven the impracticality of the AICBM. Although the United States appeared unable to defend itself from a Soviet attack though an AICBM system, it no longer had to fear the Soviet development of a similar, destabilising defense. Finally, Operations NOUGAT and STORAX, together with HARDTACK II, had honed Washington's ability to conduct nuclear testing underground, which gave it as great an advantage as it entered into the LTBT in 1963 as it had enjoyed in nuclear technology going into the test moratorium in 1958.

An important question was raised by the balance between U.S. security and the norm of nuclear testing after it was undermined by the moratorium. Glenn Seaborg best expressed this in his memoirs. He asked

> How could the nation's safety and institutions be protected in the short run without losing sight of the larger, more distant goal of a world in which the enormous energies and resources now squandered on armaments could be redirected to bettering the human condition?[145]

[144] Memorandum for Mr. Bundy from Marcus G. Raskin, 20 December 1961; Reference Copy, Box 299A; Subjects; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[145] Seaborg, *Kennedy, Khrushchev, and the Test Ban*: 62.

The achievement of the Kennedy Administration was less the signing of the LTBT as it was successfully balancing these competing dimensions. Although armaments expenditures were not stemmed by the test ban, the universal health threat posed by global fallout was, and the United States increased its sense of security at the same time. In order to agree to the LTBT, the Soviet Union presumably also felt that its series had bettered its position relative to the moratorium. Indeed, the relationship between the LTBT and both Washington and Moscow's sense of security is an intangible but important one. It is difficult to imagine one without the other; such a circumstance would have been not much different from the moratorium. This author calls for further, English-language research into the progress accomplished by the Soviet Union in its 1961 test series, and whether this progress went some way to its agreement to the LTBT.

In his remarks at the signing of the LTBT on 7 October, Kennedy described two decades filled with nuclear tests but "never empty of hope"; and, as he signed the instruments of ratification, the president remarked that "what the future will bring, no one of us can know."[146] No one could know that expanded production of nuclear weapons would lead to superpower parity in the 1970s; no one could know that through multiple independent re-entry vehicles, mobile ICBMs, stand-off cruise missiles, and long-range submarine-launched missiles, the destructive potential of the superpower arsenals would only multiply; nor, on a personal level, could anyone know that Kennedy himself would be assassinated less than seven weeks later. Despite the hopes ascribed to the LTBT, the future did not bring an effective end to nuclear tests until the end of the Cold War itself, and, fifty years after the signing of

[146] Remarks of the President at the Signing of the Nuclear Test Ban Treaty, 7 October 1963; Reference Box 47; Speech Files; Papers of President Kennedy, President's Office Files; John F. Kennedy Library.

the LTBT and twenty years after the negotiation of a comprehensive ban, the comprehensive test ban is still yet to be ratified by the United States. The LTBT – "great as it is with promise"[147] – drove testing underground and freed the world from fallout, but did not arrest the arms race.

Rather, the end of atmospheric testing acted to considerably expand underground tests. Between January and September 1963, the budget for the 1964 test series increased to the point where the total cost ended up higher than the "assumed preparations and actual conduct of an atmospheric test series" in 1964.[148] Along with the cost, the number of shots increased, and by the end of the decade almost as many tests were held underground as the totality of the eighteen years of testing that preceded the test ban. Of the 1,030 U.S. nuclear tests carried out between 1945 and 1992, 685 were conducted *after* the ratification of the LTBT.[149] Pandora's box had been closed – although the lid remained ajar.

[147] Ibid.
[148] AEC Requested 1964 Budget Amendment for Nuclear Test Ban Safeguards, 7 September 1963 and Memorandum for McGeorge Bundy, Subject: Test Ban Treaty Safeguards, 9 September 1963; both in Reference Copy, Box 266; Departments & Agencies; Papers of President Kennedy, National Security Files; John F. Kennedy Library.
[149] "United States Nuclear Tests: July 1945 through September 1992," xi.

Conclusion

The history of United States' nuclear testing between 1945 and 1963 is a vivid and exciting one, but one that is also of profound historical importance. It is a story of trailblazing scientific progress; of the improvement of weapons that came to imperil the species; of the rivalry between superpowers; of accidents and affected populations and radiological contamination; and of politics and posturing and diplomacy. The testing of the weapons that defined the consequences of the Cold War was, itself, a crucial dimension to the narrative of that conflict. The story of U.S. nuclear weapons testing is one in which a central question – why conduct nuclear tests? – was debated and held in tension between politicians, generals and scientists. It is this question that this thesis has explored.

I have argued three major points. Firstly, that nuclear weapons testing was for the most part a rational state act in which essential information was learned that was relevant to nuclear weapons and their use. This information in turn illuminated other important issues, such as the details of a test cessation agreement. Secondly, that crucial to the history of nuclear testing as a rational state act was the idea of its normalisation. This was a process that began under Truman and was in some cases a deliberate act, but was for the most part organic. The norm of testing as an acceptable state action was forever undermined by Eisenhower's moratorium of 1958-1961, which posed a political dilemma to the tests under Kennedy that was resolved only through the Limited Test Ban Treaty. Finally, this thesis argued that part of the reason Washington accepted the LTBT in 1963 was because it had accomplished all it could realistically expect from atmospheric weapons testing. I have also sought to enhance contemporary understanding of nuclear weapons development programs through a history of the experiences of the world's first and pre-eminent nuclear power, and, by doing so, contribute to a polemicised perception of nuclear weapons tests.

Testing of nuclear weapons was not a process that inevitably occurred in the aftermath of the bombing of Hiroshima and Nagasaki and the end of the Second World War. Rather, there was a very real discourse within the American political and public sphere regarding nuclear testing, and it was the victory of those who argued for national security over those who perceived the diplomatic and environmental costs of testing that normalised nuclear weapons tests. This discourse was best observed in the lead-up to the Operation CROSSROADS tests of 1946 – the first peacetime test series held by the United States, and the first series of almost two decades of atmospheric testing. With CROSSROADS, public appeals against nuclear tests as well as calls from scientists like Oppenheimer were marginalised, and the precedent for testing of nuclear weapons during peacetime and for reasons other that proof-testing was established. Although that discourse never really went away, CROSSROADS, and subsequent test series, presented both precedent and *fait accompli*, and opponents of nuclear testing struggled to overcome these until 1958.

During the presidency of Harry S. Truman, the United States conducted nuclear tests primarily for weapons design purposes, and it made rapid and impressive progress. Through important series like Operations SANDSTONE and GREENHOUSE, the U.S. increased the yield of its atomic weapons while simultaneously reducing the requirements for fissionable material like plutonium and uranium, and made crucial steps toward the hydrogen bomb. The first Soviet atomic test in August 1949 ended the American atomic monopoly and impelled the U.S. toward the hydrogen bomb, a path confirmed by Truman in his directive of 31

January 1950. By the time Truman left office, the United States had tested its first hydrogen bomb, and this achievement was the pinnacle of what was a remarkable process of weapons development. Within two test series, the United States accomplished a twofold increase in the yield of its atomic weapons; within four series, a tenfold increase; and, in only seven test series and seven years, the United States had created weapons almost five hundred times more powerful than the bomb that had destroyed Nagasaki and almost seven hundred times more powerful than the bomb that had destroyed Hiroshima.

With the normalisation of nuclear weapons testing and the development of the hydrogen bomb under Truman, nuclear testing considerably expanded during the presidency of Dwight D. Eisenhower. Test series under Truman, although trending generally upward in number and yield, nonetheless included three years in which no tests took place. Gone were these pauses under Eisenhower: every year of his presidency until the moratorium featured at least one test series, and, in the final ten months before the moratorium, three test series were conducted. These series included more and more test shots, and the total yield of Operations CASTLE, REDWING and HARDTACK Phase I was more than double the total yield of every other U.S. nuclear test carried out between 1945 and 1963 combined. Because of this extraordinary expansion, U.S. nuclear testing was at its zenith under Eisenhower. Test series during Eisenhower’s tenure made many technical accomplishments, including the miniaturisation and diversification of the U.S. nuclear arsenal that permitted warheads to be delivered by bomber, missile, rocket and artillery, but also became increasingly interested in weapons effects. The pursuit of weapons effects was best seen in the high-altitude tests of Operation HARDTACK I and Project ARGUS.

Testing under Eisenhower was suspended in October 1958 with the beginning of the test moratorium.

Flawed as the test moratorium was, its prime accomplishment was to arrest the expansion of nuclear testing that had preceded it. Although this was only a temporary success – the moratorium lasted just short of three years, after which both the Soviet Union and United States resumed extensive testing – that period of non-testing undermined the norm of nuclear weapons testing as an acceptable state action. Nuclear tests carried out after the moratorium existed as clear contrast to a period devoid of testing; indeed, the resumption of testing was a controversial violation of a political, suspension agreement. The test series carried out during the presidency of John F. Kennedy, then, assumed an overwhelming political and diplomatic significance because of their controversy; because they diverged from the moratorium; and because the moratorium had eroded the idea that testing was an acceptable, rational state action. But it was possible, after the signing and ratification of the Limited Test Ban Treaty, to say that the set of tests conducted between 1961 and 1963 were crucial to the realisation of an effective ban on atmospheric testing. The act of test resumption had discarded an ineffective suspension agreement and, in the interaction between these tests and the Cuban Missile Crisis, urged acceptance of a more durable cessation agreement in its place.

This thesis has sought above all else to show how contemporary actors rationalised nuclear testing. Part of this rationalisation has been to survey the ideas that derived from testing and to demonstrate the connection between test series and nuclear thinking. But crucial to the argument that nuclear testing was a rational state action is the question: what was learned from nuclear weapons tests? Foremost, nuclear weapons tests provided the kind of evidence-based interpretation of nuclear weapons and doctrine for their use that Michael Quinlan argued was lacking from the discourse on the topic. The tests conducted in the period covered by this thesis spectacularly demonstrated the awesome power of nuclear weapons, that same "uniquely appalling" destructiveness that Quinlan readily observed.[1] I suggest that only through a test like IVY MIKE could a true sense of the scope of thermonuclear weapons be grasped, just as CASTLE BRAVO dramatically demonstrated the threat of fallout as it has come to be understood. Similarly, the refinement of weapons and measurement of their effect aided the creation of war plans for their use; here I am thinking of Operations SANDSTONE, BUSTER-JANGLE and TUMBLER-SNAPPER, which together determined the size of the U.S. nuclear arsenal and the number of weapons to be allocated to the destruction of individual targets in the event of war. Weapons effects tests, particularly high-altitude series like HARDTACK I and DOMINIC, were vital to the development of defences against missile attacks and methods for penetrating such defences; while underground test series like PLUMBBOB and HARDTACK II generated information essential to the monitoring of a test cessation agreement, and thus had diplomatic significance. Likewise, the resumption of testing in 1961 served a political function – Operation NOUGAT, for example, acted in part as a diplomatic response from Washington produced by Moscow. And while all of these examples remain closely aligned to the spectre of nuclear conflict, there were very real scientific benefits to nuclear testing, such as in the pursuit of nuclear energy, the use of nuclear weapons as tools of excavation for great projects, and especially in the case of Project ARGUS, which provided much data on the Van Allen radiation belts that surround the Earth at a time when humanity was beginning to explore space. That nuclear weapons technology has evolved from

[1] Michael Quinlan, *Thinking About Nuclear Weapons: Principles, Problems, Prospects* (Oxford: Oxford University Press, 2009), 13-14.

plutonium, implosion-type fission bombs, and that nuclear doctrine has evolved from a single bomber dropping such a weapon on a target city, is due foremost to nuclear weapons testing.

However, as Scott Sagan and Nina Tannenwald have each in their own way noted, the norm that governed nuclear testing changed during the period covered by this thesis. Sagan, for example, questioned why "was nuclear testing deemed prestigious and legitimate in the 1960s, but is today considered illegitimate and irresponsible?"[2] Certainly there are larger issues related to proliferation embedded within this question, but related also was the delegitimisation of nuclear testing accomplished by the test moratorium, and of atmospheric testing specifically by the Limited Test Ban Treaty. I have argued that the normalisation of testing under Truman was followed by the expansion of testing under Eisenhower, and finally by the denormalisation of testing under Kennedy. There were diplomatic considerations in this process – such as the politically-threatening character assumed by atmospheric testing – as well as considerations of national security – such as the preservation of the U.S. lead in nuclear technology or in underground testing – but, rooted among these considerations, the process of denormalisation was connected to widespread concerns about fallout.[3]

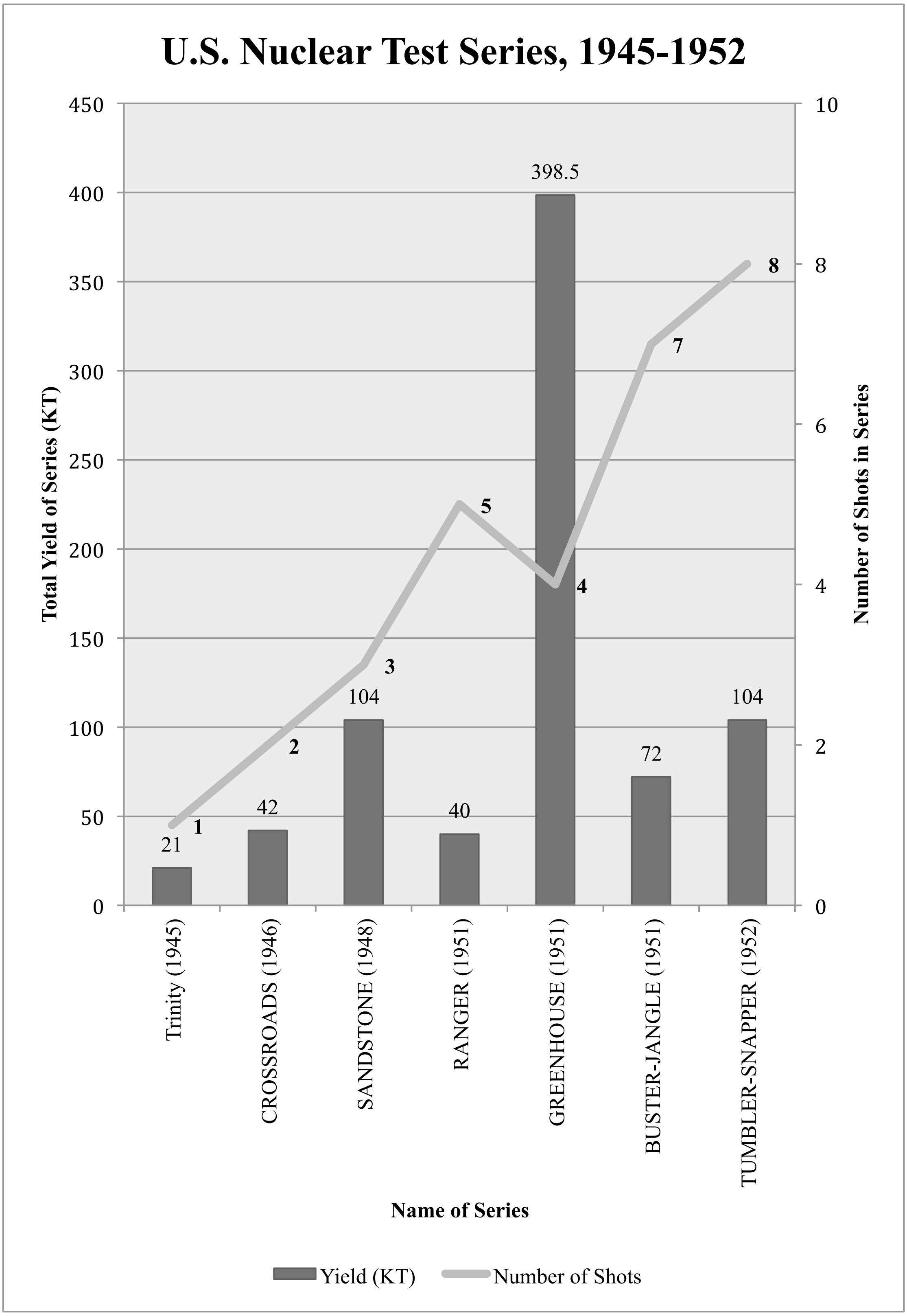
Ultimately, by the time that denormalisation had reached its apex with the Limited Test Ban Treaty, the United States had probably accomplished all it could hope for from atmospheric testing. By 1963, the U.S. had developed a varied arsenal

[2] Scott D. Sagan, "Why Do States Build Nuclear Weapons?: Three Models in Search of a Bomb," *International Security* 21, no. 3 (1996-1997): 76.
[3] As I noted in the introduction to this thesis, the relationship between nuclear testing and fallout, and between fallout and displaced and affected populations, is better explored in other sources. But testing continued underground after the Limited Test Ban largely because it contained fallout, and so removed the global fear of radiation from consideration.

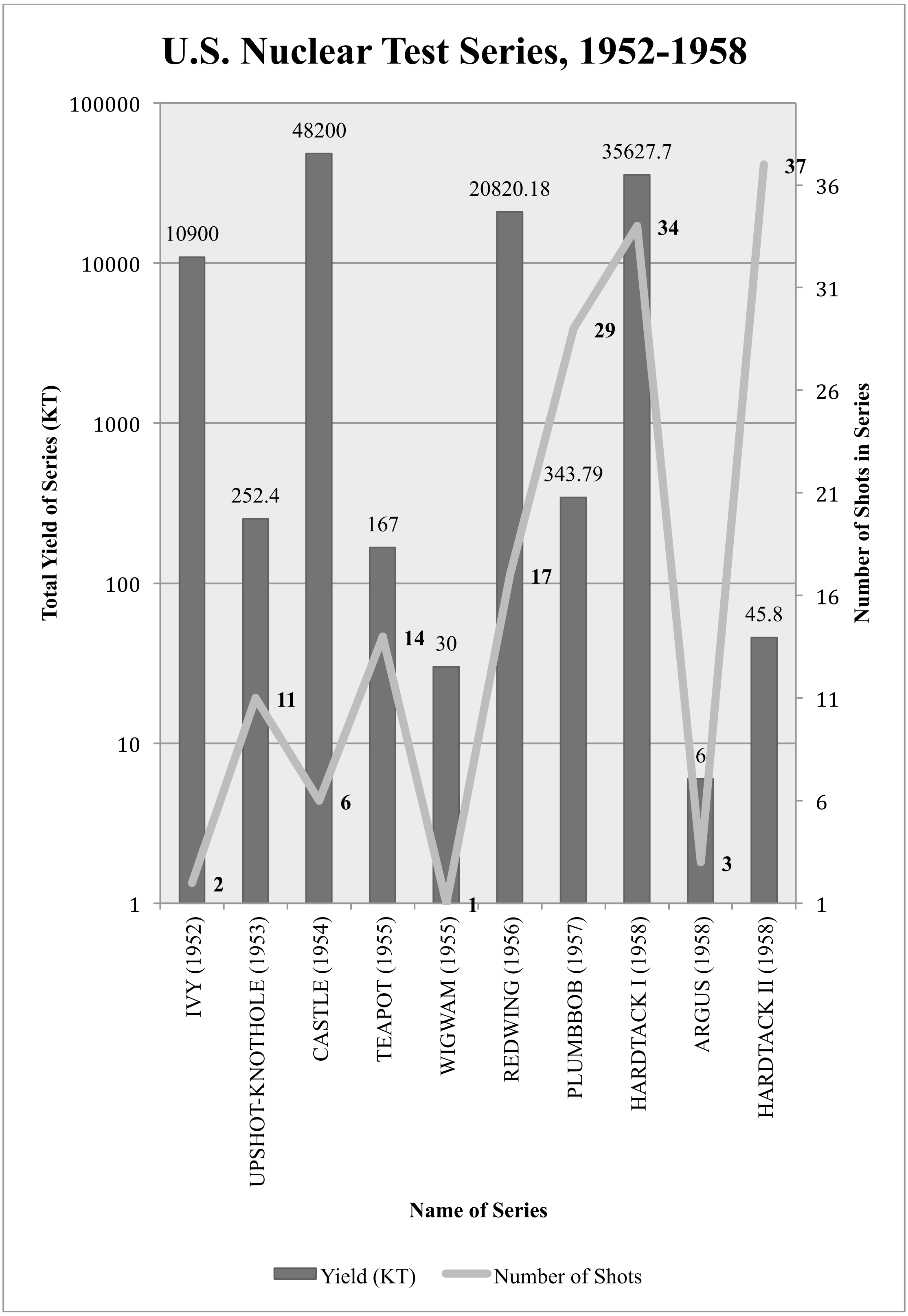
of fission, boosted fission and fusion weapons; it had proof tested many weapons systems, from strategic bombs and missiles to tactical rockets and shells; it had experimented underground, underwater, on the surface, in the atmosphere, and in orbit of the planet; and it had investigated the exotic effects of nuclear explosions at various altitudes, including radar blackout, radio disruption and electromagnetic pulse effects. Through these experiments, the United States had strengthened its security and possessed confidence in its arsenal. With the tests conducted between 1961 and 1963, the most optimistic hopes invested in the anti-intercontinental ballistic missile had been invalidated, and there were no promising, potential improvements in nuclear weapons discernable that required atmospheric testing. Although this author cannot conclude with the same confidence, it seems likely that the Soviet Union reached similar conclusions, and both powers agreed to the test ban treaty in the final months of 1963.

In addition to the arguments summarised above, this thesis has strived to demonstrate that nuclear testing was a central component of the wider history of the Cold War, in part because of its importance to the development of the weapons that defined that conflict, but also because nuclear weapons tests were tied to the shifting balance between the superpowers. That conflict and that balance were intense moments in the human story. But this author, in conclusion, wishes to stress the bigger historical picture. After millions of years of evolution, hundreds of thousands of years of prehistory, and millennia of human history, the human species had developed weapons whose destructiveness came not through the kinetic or the chemical but the nuclear, through a manipulation of the underlying structures of the universe. That species then exploded these weapons as experiments – tremendously violent and energetic reactions that awed and stunned – and, through the act, refined such weapons into a terrifying capability to destroy itself. It is unclear if Lewis Strauss was thinking in such terms, but having only recently witnessed the largest thermonuclear explosion ever detonated by the United States, it seems likely that he would have contemplated the notion when he described nuclear weapons testing as “this awesome field.”

Appendix One

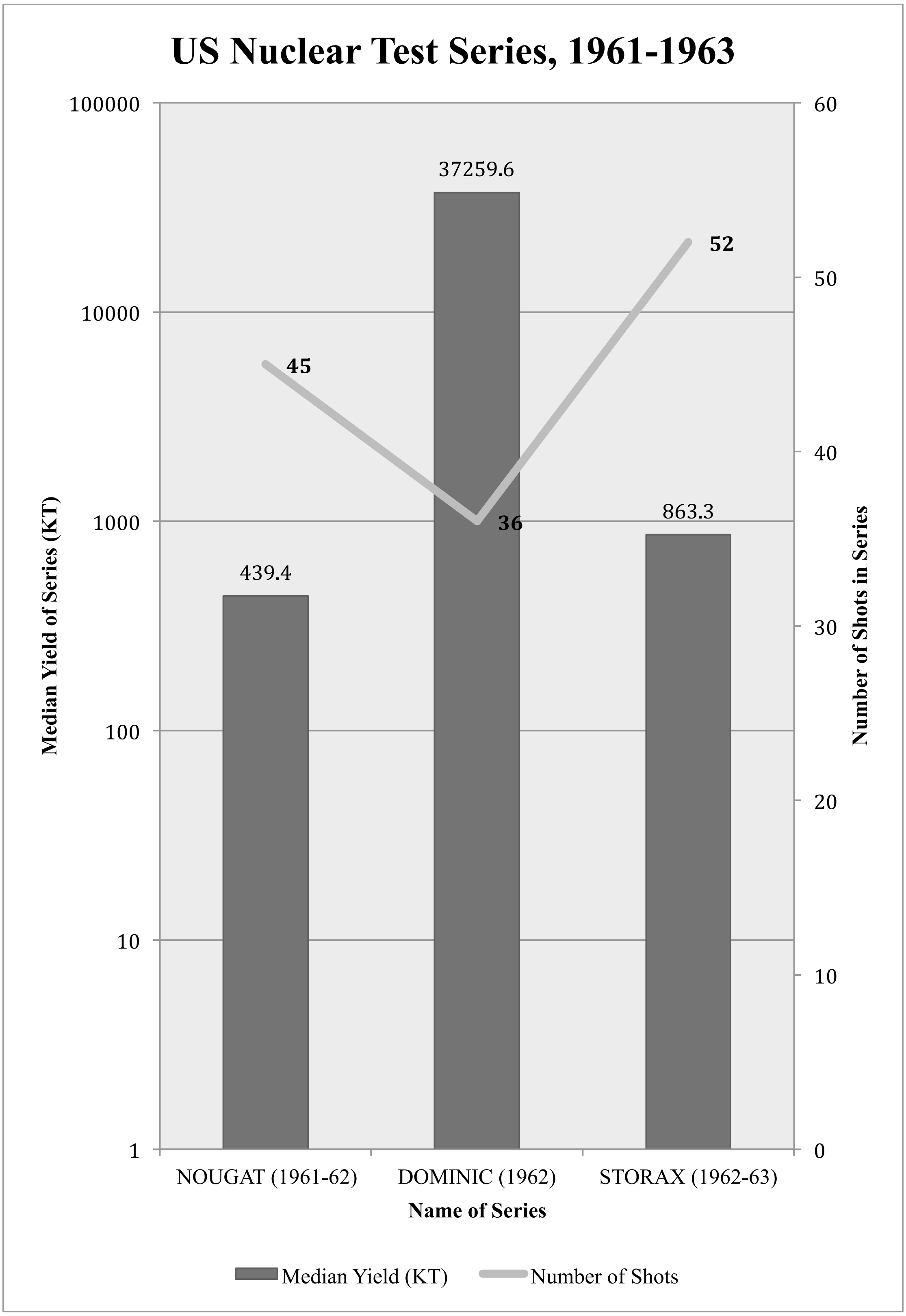


Appendix Two



Note logarithmic scale for total yield.

Appendix Three



Note median yield. Because of the AEC's obfuscatory policy of reporting the yield of many shots as a range rather than a specific figure, the calculation of a median yield for each series is inherently inaccurate. This is especially acute for STORAX.

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President's Secretary's File
PSF: Subject File 1940-1953
SMOF: Naval Aide to the President Files, 1945-1953
Student Research File

Dwight D. Eisenhower Presidential Library, Abilene, Kansas
Eisenhower, Dwight D.: Records as President
Eisenhower, Dwight D.: Papers as President of the United States, 1953-1961
McCone, John S., Papers, 1958-1961
Quesada, Elwood R.: Papers
White House Central Files, Official File, 1953-1961
White House Office
Office of the Special Assistant for National Security Affairs: Records, 1952-1961
Office of the Special Assistant for Science and Technology: Records, 1957-1961
Office of the Staff Secretary, 1952-1961

John F. Kennedy Library, Boston, Massachusetts
Papers of President Kennedy
National Security File
President's Office Files
Weekend Papers

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