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NATIONAL RESPONSES TO TECHNOLOGICAL INNOVATIONS IN WEAPON SYSTEMS, 1815 TO THE PRESENT

By

Terrence R. Fehner

Prepared for Booz-Allen & Hamilton Incorporated

JANUARY 7, 1986

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January 9, 1986

Mr. John Robert Statz
Booz-Allen & Hamilton Incorporated
Crystal Square 2, Suite 1100
1725 Jefferson Davis Highway
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Dear Bob:

Enclosed are five copies of the study entitled "National Responses to Technological Innovations in Weapon Systems, 1815 to the Present," as prepared by History Associates for Booz-Allen & Hamilton Incorporated.

We have enjoyed working on this and hope we can provide additional historical studies in the future.

Sincerely,

Phil

Philip L. Cantelon
President

Enclosures

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PREFACE

The research methodology used for this study involved mainly the identification of secondary source material. An extensive bibliographical search for relevant books and journals through use of the Scorpio computer system at the Library of Congress revealed a wide variety of scholarly studies relating to military technology and international affairs. Additional source material was examined at university, county, and municipal libraries in the Washington, D.C. metropolitan area. These bibliographical searches yielded a number of seminal works. Ideas developed through discussion with professional historians at History Associates, Incorporated proved equally useful in aiding the course of this study.

Although the influence of military technology on international politics and warfare is a relatively recent area of historical inquiry, emerging as a distinct field only in the last twenty-five years, the interest with which scholars have approached the subject has produced many informative historical studies. The following is a selected bibliographical list of books and journals used in this study.

The principal investigator for this study was Dr. Terrence R. Fehner, who holds a Ph.D in history from Georgetown University. Assisting him were Professor Robert C. Williams, Washington University in St. Louis, Professor Rodney P. Carlisle, Rutgers University in Camden, Bruce P. Montgomery, Dr. Richard G. Hewlett, Dr. Philip L. Cantelon, and Dr. Ruth A. Dudgeon.

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INTRODUCTION

How do nations react during peacetime when a potential adversary develops or acquires a technologically innovative weapon or weapons system that threatens to alter the military balance of power? In an era in which technological innovation has become a central, if not the central, consideration in determining the strategic military balance, the question has taken on increasing importance. Some of the most significant political debates of our time have revolved around technologically innovative weapons systems such as atomic bombs, anti-ballistic missiles, and, currently, the Strategic Defense Initiative. Major public concern with the "missile gap" and the "window of vulnerability" have been inspired by technological innovation and advancement. It is critically important, therefore, for policy makers to be aware of the options available when a nation threatens to acquire a military technological breakthrough. It is equally important for a nation contemplating development of innovative technology to consider how its adversary will respond to any perceived alteration in the balance of power.

This study examines historically how states have reacted during peacetime to a potential adversary who acquires or develops innovative technology that threatens to upset the military balance of power. An historical perspective can aid policy makers with additional information and insights of analogous situations in order that they may better understand the present. An awareness of reactions to technological innovation in the past may not allow one to predict exactly how a competing state will respond, but it does allow one to make reasoned, informed, and intelligent estimates of the options available.

The study focuses on the period from 1815 to the present, from the beginning of the Industrial Revolution to the latest developments in military technology. Innovative technologies are defined as those developments which significantly alter the military balance of power between nations so as to place the state without the new technology at a distinct and precarious military disadvantage. The action and posture of the state acquiring the innovative technology is of interest only in terms of its impact on the state without such technology.

The study comprises five sections and a conclusion. Section I discusses the Industrial Revolution's impact on military technological innovation during the nineteenth century. Section II examines the role of the submarine and the airplane as technological innovations that revolutionized the nature of warfare. Section III describes how World War II witnessed the first real joining of science and technology with national defense and details the response of the Soviet Union to the American monopoly of the atomic bomb. Section IV describes the reactions of third powers to the possession of nuclear weapons by the United States and the Soviet Union. Section V discusses the central role that science and technology have played in determining the strategic military balance since 1945 and focuses on the delivery systems arms race between the Soviet Union and the United States during the past three decades. The conclusion analyzes the four basic historical responses of states during peacetime when a potential adversary develops a technologically innovative weapon or weapons system.

I. TECHNOLOGY OF THE INDUSTRIAL REVOLUTION

Technological innovation has influenced warfare since antiquity. But the development of new technology and the peacetime application of that technology to specific military purposes became a prime consideration for military and political leaders only within the last century and a half. Technological breakthroughs throughout most of history have been few and slow to develop. The introduction of gunpowder and firearms in the late Middle Ages, for example, radically changed the nature of warfare, but their development was gradual and piecemeal. The new weapons proved their worth on the battlefield through a process of trial and error, and their effectiveness was at first only slight. Since weapon-making for centuries occurred within a limited and stable technological framework, the development of new and innovative weapons evolved very slowly.[1]

The onset of the Industrial Revolution, however, rapidly increased the rate at which nations developed and applied new technology to warfare. In the nineteenth century, military practitioners either ignored technological innovation or perceived it with suspicion. They understood neither the potential military significance of new technologies nor their application on the battlefield. The

French Revolution and its accompanying wars witnessed the first modern attempt, by the beleaguered French government, seriously to promote technological development for military purposes. The French introduced, for example, a balloon corps, to permit aerial observation of enemy troops, and a semaphore telegraph, connecting Paris with the front. The Restoration of 1815, however, represented a triumph for a conservative mindset that clung to the old, pre-revolutionary ways of war and resisted changes in weaponry and tactics. This outlook dominated military thinking regarding warfare on land and sea until mid-century.[2]

Most of the nineteenth-century technological innovations that dramatically changed the nature of land warfare occurred between 1850 and 1870. Military strategists, however, generally failed to see the significance of modern weapons until they were actually used on the battlefield. Thus, when the newly issued rifled handguns of the British and French proved clearly superior to the old-fashioned muskets of the Russians during the Crimean War, other European powers rapidly adopted the innovation. Similarly, Prussian success with the breech-loading rifle in the Austro-Prussian War of 1866 and with breech-loading steel artillery in the Franco-Prussian

War of 1870-71 precipitated a rapid changeover to battle-proven new designs. These weapons gave a distinct advantage to defensive warfare, and, with the deployment of the machine gun, the next conflict would bring stalemated trench warfare quite different from the quick and decisive wars of mid-nineteenth-century Europe.[3]

Military planners, however, failed to foresee the consequences of the new weaponry. The primary lesson drawn from the Prussian successes of 1866 and 1870 was that it was advances in transport and industrial production, and not technologically innovative weapons, that had proven decisive. The integrated rail network of Prussia had enabled the Prussians to mobilize large armies equipped with mass-produced, inexpensive weapons more readily than its adversaries. Industrialization was the key to equipping and transporting mass armies, and after the Franco-Prussian War military victory in land warfare was viewed as depending on a combination of manpower and an integrated rail network. Hence, Germany's concern before the First World War was that Russia's developing rail system would give the numerically superior Russian armies a decisive advantage.[4]

Before the First World War, European militaries resisted technological innovation in weapons. An integrated rail network could bring troops close to the scene of battle, but delivery of supplies from the railhead to the battlefield itself still depended on horse transport. It was difficult enough to provide support for a mass army. New weapons such as machine guns required enormous amounts of ammunition, and artillery could prove to be so large and heavy that horses would not be able to pull it. The military was reluctant to strain an already overburdened support system.[5]

There was thus little fear before 1914 that in the area of land weaponry a technological breakthrough would seriously alter the military balance of power. Beginning with the 1840s, however, technological developments in naval weaponry threatened to upset, perhaps decisively, the military balance at sea. Naval planners, political leaders, and even the informed public realized that military advantage could accrue from technological change. This struck hardest, in terms of a perceived threat to national security, at the British. British command of the sea following the Napoleonic Wars was an acknowledged fact, and any technological change initiated by another power became a potential challenge to British superiority.[6]

Throughout most of the nineteenth century, France was the only country with both the motivation, based on a long and bitter naval rivalry, and the technological and industrial capability to challenge British command of the sea.[7] The French, acutely aware of British numerical superiority in ships and the inability of French shipyards to outbuild their British counterparts, repeatedly turned to technical innovation in an attempt to redress the military balance. France thus initiated most of the major technical naval innovations during this period, but it was unable to translate these into naval superiority over, or even parity with, the British. France could not maintain a monopoly on technological innovations and was incapable of sustaining a naval challenge as a primary political priority. France was a land power foremost, and her national security ultimately did not depend on naval power.[8]

The British pursued technological change with reluctance. Since the maintenance of the status quo was to their advantage, it was the policy of the British navy not to introduce an innovation which would make existing weaponry obsolete. Nonetheless, French efforts served as a catalyst to new British endeavors. Such was the case with the application of steam propulsion to naval vessels, arguably the most significant technical advance of the century. With steam propulsion, warships no longer had to rely on the vagaries of the wind. The mobility of steam-powered warships fundamentally changed naval warfare and made existing vessels obsolete. Yet, the British navy resisted steam propulsion, as an Admiralty memo of 1828 noted:

> Their Lordships feel it is their bounden duty to discourage to the utmost of their ability the employment of steam vessels, as they consider that the introduction of steam is calculated to strike a fatal blow at the supremacy of the Empire.[9]

As incorrect as this British position proved to be, it was based on solid reasoning. The British contended that with the implementation of a steam-powered navy, all naval powers would start from the same position, thereby negating Britain's overwhelming dominance in sail warships. In addition, although early steam-powered vessels were more manueverable, they were also inefficient and extremely vulnerable to attack. Exposed paddlewheels were easily destroyed by gunfire. With the advent of the screw propeller, however, the demise of the sail warship became imminent, since the machinery was contained within the ship and below the waterline.[10]

France pioneered the adoption of steam propulsion and screw propellers on naval vessels. In 1846 the French embarked on a major program to expand their steam fleet, increasing naval expenditures 17 percent over the previous year. The French naval program alarmed the British. Lord Palmerston, Britain's prime minister, had warned the House of Commons the previous year that the English Channel had become "nothing more than a river passable by a steam bridge."[11] Fear of an incipient French invasion spread throughout Britain, and the British navy responded with a crash program to convert a large portion of the fleet from sail to steam. By 1848 the British had clearly outdistanced the French in steam construction. The invasion panic, however, remained largely unabated until the government, in response to demands for even more armaments, proposed increased taxes to augment land defense forces. Since new taxes caused more immediate concern than the French, the invasion scare quickly subsided.[12]

The steam-powered ships added to the British fleet were not capital ships, but frigates and auxiliary vessels. The British believed that the traditional two- or three-tiered ship of the line did not lend itself to conversion to steam power. But in 1851, France launched the Napoleon, the first high-speed, steam-powered ship of the line. This event destroyed the recently regained complacency of the British Admiralty, and, as a second invasion panic set in, Britain responded once again with a significant warship construction program. Britain also reacted by greatly expanding expenditures on coast and land defense. The British army used the invasion scare to enhance its own position and role within the military establishment.[13]

The two invasion panics and the increased defense expenditures were reactions by the British to technical innovation by France. But the intensity and degree of reaction stemmed from international and domestic political factors. The traditional British-French rivalry intensified in the 1840s after France openly declared its intention to achieve naval parity with Great Britain. Within France, political instability during the revolution of 1848 and the rise to power of Louis Napoleon, whom the British believed to have ambitions similar to those of his famous uncle, exacerbated the rivalry. Domesticly, British special interests, particulary those associated with the army, exploited the invasion scare to their own advantage. The British had legitimate concern with the military implications of French technological innovation. But the British reaction had a degree of irrationality to it and was not proportional to the nature of the threat. British naval expenditures had always outpaced those of France; there was a lack of comprehension that, although steam made a channel crossing less difficult, it at the same time made it easier to defend against such a crossing. The French themselves, especially after 1848, tried to placate the British and avoid direct competition.[14] British security, therefore, was never seriously in danger.

A third panic, nonetheless, struck Britain in the late 1850s as invasion fears were fanned by increased tensions with France and the French construction of the first seagoing ironclad fleet. Tests with new rifled ordnance in 1857 convinced the French that wooden ships were no longer feasible as warships, and, in the midst of a major building program, they launched the *Gloire*, the first seagoing ironclad, in 1859. Even before the *Gloire* was completed, the British had responded with a program to build their own ironclads. As Sir Baldwin Walker, surveyor of the navy, reported to the Admiralty in June of 1858: "France has now commenced to build frigates of great speed with their sides protected by thick metal plates and this renders it imperative for this country to do the same without a moment's delay."[15] At the same time, the British urgently began efforts to develop armament capable of penetrating the *Gloire*'s armor. Once again, coastal defenses and fortifications became a focus of attention.[16]

The French advantage, as with previous panics, was more perceived than real. Though technologically innovative, France possessed neither the industrial resources nor the sustained motivation to keep pace with the British. From the 1860s until the end of the century, unparalleled technological change in ship design and construction continued unabated. Yet Britain maintained her naval superiority, not because she was on the forefront of technological innovation, but because her industrial and shipbuilding base gave her the capability to outbuild quantitatively any potential competitor.

Throughout most of the nineteenth century, the fruits of technological innovation in naval weaponry, even with revolutionary changes in design that proceeded at a frenetic pace, were simply not viewed as national resources to be protected and, if possible, monopolized. Nations did not attempt to conceal the design or numbers of ships they were building. Facts and figures concerning vessels planned or under construction were published in government reports, and shipyards were open to foreign visitors. Secrecy that did exist was usually of a commercial rather than a military nature. Private firms protected industrial processes and inventions by the use of patents, but patents were frequently sold or stolen.[17]

By the 1860s the industrial armaments business had grown global in nature and was producing the most technologically advanced weapons available. Shipbuilders and armament manufacturers sold to any nation willing to pay the price. Nations lacking either a technological or an industrial base were able to purchase the world's most technologically innovative weapons. Thus, Chile in 1882 purchased a cruiser, from a British manufacturer, that was superior to any comparable ship in the British fleet.[18]

As long as Britain remained industrially predominant in the world, she was not overly concerned that the existing technological free market could jeopardize her strategic superiority. But in the later years of the nineteenth century, her relative industrial advantage, especially in relation to the United States and Germany, began to deteriorate. At the same time, the British Government began to interact increasingly with private manufacturers with regard to weapons development, specifying performance characteristics for new guns, armor, or ships. Technological innovation, in effect, began to become deliberate as these specifications challenged engineers to come up with appropriate designs. Equally important, the government began to underwrite design and testing. As a result of the closing industrial gap and increased governmental input in the development of weapons by private manufacturers, the British Government placed restrictions on what technical secrets could be shared with foreigners.[19]

British awareness of the importance of protecting technical secrets encouraged the corresponding realization that taking the lead in technological innovation could be more advantageous than waiting to respond to the technological developments of a potential adversary. The building and launching of the _Dreadnought_ in 1906 signaled the end of the century-long avowed policy of resistance to technological change. The individual technologies that went into the _Dreadnought_ were relatively simple and well-known. What made the warship innovative was the combination of existing technologies into one vessel that outclassed all existing warships in terms of superior speed and firepower.[20]

The British were well aware of the implications the _Dreadnought_ held for the existing balance of naval power. As Admiral Sir John Fisher, principal advocate for the building of the _Dreadnought_, noted in June of 1906, the building of the ship would "mark the beginning of a new naval epoch. For. . . all existing battleships--even the most modern--will be practically obsolete. . . today all nations start de novo. . . ."[21] Since Britain possessed by far the largest number of existing battleships that would become "practically obsolete," she was the one nation most likely to be disadvantaged by the introduction of a revolutionary type of battleship. Fisher reasoned, however, that whatever Britain did, other nations would be building similar warships in the near future. Britain would be less at a disadvantage if she took the lead. Fisher ordered the Dreadnought built in absolute secrecy, and it marked the first time a nation had attempted during peacetime to conceal the characteristics of the warships it was constructing.[22]

The development and building of the Dreadnought in secrecy gave the British a significant lead in implementing a revolutionary type of weaponry. For eighteen months, while the Dreadnought was being built, the naval programs of rival powers remained paralyzed. Germany had emerged at the turn of the century as the major naval competitor to the British, and once the general specifications of the Dreadnought became public knowledge in 1906, German naval planners reevaluated their position. The Germans now faced the choice of matching the British innovation by building dreadnought-type battleships of their own or acquiescing to

British naval superiority. Germany decided to build its own fleet of dreadnoughts, but she started from a position already considerably behind that of the British.[23]

Other nations were quick to imitate the secrecy that the British had employed in the building of the *Dreadnought*.[24] Thus, by the first decade of the twentieth century, technological innovation, at least inasmuch as it applied to naval weaponry, was viewed as a national resource to be promoted and protected. The coming of the First World War did much to hasten this process, but it was not until the Second World War that it reached its full fruition.

II. INNOVATIVE TECHNOLOGIES OF THE EARLY TWENTIETH CENTURY

The *Dreadnought* effectively revolutionized the nature of battleship development, but it did not radically alter the nature of warfare itself. In the early twentieth century, however, there were two technological innovations that would revolutionize the nature of warfare: the submarine and the airplane. Yet, neither of these innovations were military breakthroughs in the sense that their implementation as weapons systems during peacetime created a perceived alteration of the balance of power. There are three primary reasons for this. First, both the submarine and the airplane had a distinctly evolutionary development from the crude original prototype to its use as an effective weapon of war. Revolutionary consequences came only after a long period of technological evolution, and by then use of the technology was widespread. Second, the effective use of the submarine and the airplane was not clear to military strategists until demonstrated by an actual wartime situation. As weapons, their mission or operational function was undefined or mistakenly defined. Finally, governments and their military services lacked adequate systems for incorporating innovative weapons into the military establishment. The bureaucratic structure necessary for translating a technological innovation into an actual weapon was lacking.

The technological innovations discussed in section I -- steam power, ironclads, and the Dreadnought -- represented qualitative improvements in the continued development of the capital ship. Military advantage eventually accrued to the nation that could build the most capital ships, and this was, throughout the nineteenth century, Britain. The submarine, however, represented a different type of innovation. From its earliest inception, the submarine was conceived and developed as a defensive weapon to be used against a dominant seapower. It is not surprising, therefore, that in the latter half of the nineteenth century it was the French, preoccupied with the possibility of war with Britain, who were on the forefront of the development of the submarine. As French Admiral de la Graviere observed, "Everything which threatens les colosses and tends to emancipate les moucherons should be warmly welcomed by the French Navy."[25]

Britain became concerned only when France began to evidence a keen interest in the submarine as a major weapons system. But Britain wanted to negate whatever advantage the submarine might give the French rather than develop a similar submarine capability. According to the First Lord of the Admiralty, Viscount Goschen, in 1890,

> The submarine boat, even if the practical difficulties attending its use can be overcome, would seem, so far as the immediate future is concerned, to be essentially a weapon for maritime Powers on the defensive, and it is natural that those nations which anticipate holding that position should endeavor to develop it. The question of the best way of meeting its attack is receiving much consideration, and it is in this direction that practical suggestions would be valuable. It seems certain that the reply to this weapon must be looked for in other directions than in building submarine boats ourselves, for it is clear that one submarine boat cannot fight another.[26]

In actuality, none of the major powers before the First World War viewed the submarine as a particularly important or effective weapon. Neither developing it nor negating it was, therefore, of primary importance. Moreover, France lost much interest in the submarine in the first years of the twentieth century as she ceased to perceive Britain as the chief potential adversary. At the same time, the Germans, who would discover in the First World War that the submarine was by far their most significant naval weapon, were lukewarm toward its adoption and development before 1914. Admiral von Tirpitz considered the submarine as a purely defensive weapon, suitable only for defending coastlines and, as a result, not appropriate for Germany's needs. It was, in addition, Tirpitz's avowed policy not to adopt new weapons until their military usefulness had been demonstrated. Nevertheless, Germany did forestall in 1905 the sale by a German firm to the French Navy of advanced diesel engines for installation in submarines. And in the years immediately prior to the First World War, there were some within the German navy who viewed the submarine as a weapon of increasing importance.[27]

General lack of interest in the submarine was directly attributable to the fact that no one foresaw the effectiveness of the submarine as a commerce destroyer. French naval tacticians and strategists at the turn of the century had proclaimed the submarine as an effective means of conducting a "guerre de course," and the British at various times expressed their apprehension over the submarine's potential for commerce raiding. But no one predicted that it would have the devastating impact that it did in the First World War.[28] Once Germany made the decision to wage unrestricted submarine warfare around the British Isles, the tactic very nearly succeeded in knocking Britain, which had ruled as undisputed sovereign of the seas for over a century, out of the war.[29]

The British in 1917 and 1918 were able to develop successful means of countering the submarine -- using convoys, aircraft surveillance, hydrophones, and depth charges -- which, in combination with the entrance of the United States into the war, were able to stem the tide of Germany's submarine campaign. Ultimate British success, and the fact that anti-submarine development progressed at a greater rate in the postwar years than submarine development, left the impression that the submarine problem had been and could be dealt with. Thus, it took the Second World War to demonstrate how deadly the submarine could be.[30]

The airplane, like the submarine, was a truly innovative weapon that provided no nation, least of all the one where it was invented, with a peacetime military breakthrough. The inventors of the airplane, the Wright brothers, had no connection with the United States military or government, and when interest was finally expressed in their invention in 1905 it was by the British. The Wrights tried to interest the United States Government in the airplane, but they did not receive a favorable response. Whatever the Wrights would have done, however, would not have prevented the dispersal of the technology. The application of the internal combustion engine to an aerodynamically suitable craft was, once accomplished, something that could be duplicated in other countries.

Within ten years of the maiden flight of the Wright brothers airplane, the innovation was being experimented with in all of the technologically-advanced countries.[31]

But building and experimenting with the airplane and integrating it organizationally and strategically into the military were two different things. The British were more successful at this integration than anyone else in the years before the First World War. They established the Royal Flying Corps, with an Experimental Branch, and by 1914 the British military had already experimented with using the airplane for torpedo attacks, bombing, and machine gunnery. The United States military, by contrast, only reluctantly adopted the airplane as part of the Army's Signal Corps. As a result, the United States lagged behind the major powers of Europe both in technological development and in defining the tactical use of the airplane. The onset of the First World War accelerated the development of the airplane in Europe, and concern that the United States was technologically deficient resulted in the creation in 1915 of the National Advisory Committee for Aeronautics (NACA) to study "the problems of flight with a view to their practical solution."[32]

World War I witnessed an unprecedented effort by all combatants to organize science and technology for military purposes. In the United States, for example, NACA was only the first such institution created to bridge the gap between scientific and technological advancements and practical implementation. During the war, both sides used new military technologies on the battlefield. Although rapid-fire weapons, gas warfare, and the tank promised significant military advantages in land warfare, these advances demanded corresponding innovations in strategy and tactics before they could be effectively exploited. Military tacticians, faithful to existing doctrinal preferences and practices, simply refused to believe that new military technologies could make a difference in wartime. Significant advances were made in highly technical fields like aviation and underwater acoustics, but World War I was ultimately fought and won with weapons that had been in existence at the outset of the War. The war was one in which quantity triumphed over quality. The Germans were never really defeated on the battlefield. After four years of war they succumbed to a shortage of resources and were simply outproduced.[33]

The First World War, in effect, decided little as to the role to be played by innovative technologies in the next war. The war demonstrated, for instance, that the airplane could do much more than simply provide reconnaissance. But in the postwar years there was little agreement on the precise nature of the airplane's role and whether or not it would be a decisive factor in warfare.[34] In addition, few military theorists in the interwar years would have predicted that air support and armor could be used to significant advantage. The brilliance of the blitzkrieg lay in Germany's ability to develop new tactics that fully utilized the strengths of the new technologies, creating a highly mobile, operational fighting force. The allied powers possessed the same technologies as Germany but lacked the strategic foresight of the German high command to exploit new weapons. Thus, in the years between the wars, the problem was not that one nation possessed technologically innovative weaponry and the other powers did not. The technology was diffused. The problem was one of strategy and tactics: what to do with the military weapons that had evolved through technological innovation.

III. WORLD WAR II AND THE ADVENT OF NUCLEAR WEAPONS

World War II witnessed the first real joining of science and technology with national defense. In the late 1930s, as the imminence of war accelerated the pace of weapon improvement and manufacturing, there was a growing awareness among major military powers that some new secret weapon might be developed that would decisively tip the military balance. The outbreak of war in Europe in 1939 further awakened Americans to the need to organize science and technology for the development of innovative weaponry. Thus, President Roosevelt established the National Defense Research Committee (NDRC), whose authority extended only to weapons research, in 1940 and the Office of Scientific Research and Development (OSRD), which eventually took responsibility for virtually the entire program of wartime research, in 1941. Together they drew scientists into the United States' war effort at an unprecedented rate, and brought the scientific and military communities into close collaboration.[35]

All the major powers attempted to organize science and technology for war. Britain, for example, brought its scientific community into the war effort even more efficiently than the United States. Germany, however, did not fully mobilize its scientific and technological resources until 1942 when it became clear the war would not end as quickly as expected. Once mobilized, the Germans made tremendous advances, particularly in aerodynamics and rocketry.[36] Nevertheless, as in World War I, the application of innovative science and technology did not make the decisive difference, except perhaps for the use of radar in the defense of Britain, in the war's effort. Although the weapons used at the end of the war were significantly different from those available at the beginning, the allied forces emerged victorious primarily as the result of superior industrial production. Qualitative improvements of existing weapons were more important in determining the war's outcome than new, innovative weapons. Innovative technology such the proximity fuse and jet aircraft did not mark the difference between victory and defeat.[37]

The most significant weapon developed during World War II, and one that was truly a breakthrough, was the atomic bomb. A team of German physicists had split the atom in late 1938, and this development prompted Leo Szilard, an emigre physicist from Hungary who feared that Germany would now embark on research that might lead to an atomic weapon, to try to convince the United States to support similar research. Szilard, realizing he lacked the stature to stimulate such a research program, approached Albert Einstein and persuaded him to sign a letter to the president drafted by Szilard. The letter stated that a nuclear chain reaction was almost certain to be achieved in the immediate future, and it noted that the development of an atomic weapon was a distinct possibility:

> This new phenomenon would also lead to the construction of bombs, and it is conceivable -- though much less certain -- that extremely powerful bombs of a new type may thus be constructed. A single bomb of this type, carried by boat and exploded in a port, might very well destroy the whole port together with some of the surrounding territory.

The Szilard-Einstein letter recommended the establishment of a liaison between government and scientists and advocated the use of federal funds to speed research. The letter emphasized why such steps were necessary:

> I understand that Germany has actually stopped the sale of uranium from the Czechoslovakian mines which she has taken over. That she would have taken such early action might perhaps be understood on the ground that the son of the German Under-Secretary of State, von Weizsacker, is attached to the Kaiser-Wilhelm-Institut in Berlin where some of the American work on uranium is now being repeated.[38]

The letter prompted Roosevelt to order the organization of a joint government-scientific research program, appointing an Advisory Committee on Uranium, chaired by Lyman Briggs, head of the National Bureau of Standards, and consisting of scientists and representatives of the army and the navy.[39]

The military component of the advisory committee failed to see any short-term benefit from supporting research and development of such a theoretical nature. When the committee met, the army representative expressed open skepticism about spending money on research in which the end results were so uncertain. He insisted that it would be naive to think that the outcome of a war might depend on the development of a new explosive. It usually took two wars, he said, to develop a new weapon, and it was morale, not new arms, that brought victory. One of the scientists replied that if armaments were so comparatively unimportant, then perhaps the army's budget ought to be cut by 30 percent. "All right," the army representative snapped, "You'll get your money."[40]

Progress in nuclear research over the next two years, however, was slow. Momentum increased in mid-1940 with the formation of the NDRC, to which the Advisory Committee on Uranium reported. In October of 1941, Roosevelt gave the go-ahead to expedite research and planning in every possible way. The Manhattan Engineer District was created in the summer of 1942, and during the war years, spent $2 billion to develop the atomic bomb. The military payback was manifest in the bombs dropped on Hiroshima and Nagasaki.[41]

Nuclear weapons have certainly been the most significant military technological innovation of modern times, if not all time. A nation without nuclear weapons facing the prospect of war with a nation generously supplied with nuclear weapons has already lost the war before the first shot has been fired. In 1945 the United States held a monopoly on nuclear weapons, and during the immediate postwar years it was clear that the United States' only major rival was the Soviet Union. It was equally clear to the Soviet Union that if the United States were to use nuclear weapons, it would be against the Soviet Union. The Soviets responded to the distinct American technological advantage in several different ways.

First, and foremost, the Soviets attempted to acquire nuclear weapons for themselves. Shortly after returning from Potsdam and his meeting with Truman in mid-August 1945, Stalin summoned the leading Soviet nuclear scientists and representatives of the munitions industry to the Kremlin. "A single demand of you, comrades," said Stalin. "Provide us with atomic weapons in the shortest possible time. You know that Hiroshima has shaken the whole world. The balance has been destroyed. Provide the bomb--it will remove a great danger from us."[42] Stalin then asked how long it would take to build an atomic bomb. The scientists replied that if they were given full support it would take five years. In reality, the first Soviet test took place four years later.[43]

The United States' success in building an atomic bomb was an unwelcome development for the Soviet Union, but it did not come as a surprise. As early as 1942 Soviet spies informed Moscow of the Manhattan Project, and the Soviets' own program to build a bomb antedated Hiroshima. With the discovery of nuclear fission in 1938, Soviet physicists perceived its significance as readily as their Western counterparts. As a leading Soviet physicist remarked to a group of students in 1939, "Do you know what this new discovery means? It means a bomb can be built that will destroy a city out to a radius of maybe ten kilometers."[44]

Soviet work on nuclear fission paralleled that done elsewhere. Soviet officials, however, were not enthusiastic about potential military benefits of nuclear research, and the German invasion of 1941 brought nuclear research to a halt. But in 1942, as information on British, American, and German work on an atomic bomb became available, the Soviets reconsidered and Stalin initiated a small-scale project in early 1943. By 1945 the Soviet Union had a serious atomic bomb project under way. Information passed by Klaus Fuchs and other atomic spies enabled the Soviet Union to develop an atomic bomb a year or two earlier than otherwise would have been possible, but the Soviet accomplishment of building the bomb was primarily attributable to the competency of the Soviet Union's own scientific and technological community.[45]

The second Soviet strategy for dealing with the American monopoly of the atomic bomb was to attempt to negate any military or political advantage that the United States might derive from its monopoly. In the immediate postwar years, the Soviet Union attempted to downplay the significance of nuclear weapons. In September 1946, for example, Stalin said, "I do not consider the atomic bomb as serious a force as some politicians are inclined to do. Atomic bombs are meant to frighten those with weak nerves, but they cannot decide the fate of wars since atomic bombs are quite insufficient for that."[46]

More important as a counterweight to American nuclear weapons was Soviet reliance on strong conventional military forces, especially at forward bases in Eastern Europe. These, in effect, held Western Europe hostage because there was no comparable force in the West. United States atomic weapons might destroy Soviet cities, but the Soviet army could strike at Western Europe. As an additional deterrent against attack during the post-war years, the Soviet Union modernized its conventional weapons and strengthened its air defenses.[47]

A third Soviet response to American atomic monopoly was to negotiate an international agreement that would eliminate or minimize the nuclear threat by bringing atomic weapons under international control and mandating the destruction of all existing atomic bombs. It is difficult to determine if the Soviets placed any real hope in negotiations which might resolve their nuclear disadvantage. But in the period immediately following the war, they were willing to listen to American overtures and responded with proposals of their own.[48]

The most significant attempt at negotiation occurred in 1946 when the United States proposed the Baruch Plan, which envisioned the international control of atomic energy and the establishment of an International Atomic Development

Authority. The International Authority would possess a virtual monopoly on all forms of production of atomic energy, and it could impose sanctions by a majority vote of its members on any nation found in violation of the agreement. Only when the Authority was effectively established would the United States relinquish control of its own atomic weapons. The Soviets, unwilling to give up veto power in any scheme of international control, countered with the Gromyko Plan, which envisaged an international convention requiring the destruction of all existing atomic weapons and prohibiting the production and use of any such weapons in the future. The plan provided for neither international inspections nor sanctions. Had the Gromyko Plan actually been implemented, it would have effectively disarmed the American monopoly at virtually no cost to the Soviets. Consequently, with the two sides so far apart, no agreement was reached.[49]

In response to the American development and monopoly of the atomic bomb, the Soviet Union evolved a distinct pattern of reaction to technological innovation by the opposing superpower. This pattern has been consistently repeated in the arms race between the United States and the Soviet Union. When one superpower has developed or threatens to develop a technological innovation that is perceived as a threat to the military balance, the other superpower responds by 1) obtaining similar technology for itself, 2) negating the technological advantage by other means, and/or 3) negotiating to maintain or restore the balance. At times, as with the atomic bomb, all three responses are elicited. Few instances of superpower technological response in the last forty years, however, have been as clear-cut as that of the atomic bomb. In the complex areas of scientific research and the development of military weapons, both sides frequently have developed similar technologies simultaneously. Consequently, when one superpower attains a technological advantage, the other often responds by accelerating a developmental program of its own. And so the technological race continues. The development of thermonuclear weapons is a case in point.

The development of a thermonuclear weapon -- or a superbomb -- was first suggested by American physicists in 1942.[50] Although some theoretical work was done on the superbomb during the war, development of the atomic bomb had taken overwhelming precedence. In the spring of 1946, an expanded research program began concentration on the theoretical problems of the superbomb. From then until 1949 approximately half of the Los Alamos Scientific Laboratory's Theoretical Division was working on thermonuclear research.

During this same period, the vast majority of non-theoretical work of experimental scientists and engineers was devoted to fission and not fusion. In 1948, the Soviets, in response to reports -- possibly from Klaus Fuchs -- of thermonuclear research in the West, set up a theoretical group to study the possibility of building a superbomb. In the fall of 1949, before the United States made the decision to move beyond the theoretical stage and actually attempt to develop a superbomb, the Soviet Union began to work on the development of a thermonuclear weapon as a matter of priority.[51]

The Soviet testing of an atomic bomb in August 1949 spurred debate in the United States on whether to pursue the actual development of a superbomb. Despite the opposition of the General Advisory Committee of the Atomic Energy Commission (AEC), President Truman in January 1950 decided to accelerate the development of the new weapon. One of the major arguments for proceeding was that the Soviets possessed the capability for developing the superbomb; and if they possessed the capability, they would actually build it. Senator Brien McMahon, chairman of the Joint Committee on Atomic Energy, wrote Truman that, "If we let Russia get the super first, catastrophe becomes all but certain -- whereas, if we get it first, there exists a chance for saving ourselves."[52] In a similar vein, Lewis Strauss, AEC Commissioner and soon to be chairman, wrote the president:

> Recent accomplishments by the Russians indicate that the production of a thermonuclear weapon is within their technical competence. . . . The possibility of producing the thermonuclear weapon was suggested more than six years ago, and considerable theoretical work has been done which may be known to the Soviets -- the principle has certainly been known to them. The time in which the development of this weapon can be perfected is perhaps of the order of two years, so that a Russian enterprise started some years ago may be well along to completion. . . . The danger in the weapon does not reside in its physical nature but in human behavior. Its unilateral renunciation by the United States could very easily result in its unilateral possession by the Soviet Government. I am unable to see any satisfaction in that prospect.[53]

With Truman's decision, the United States embarked on a priority program to develop the superbomb, and the first experimental test of a large thermonuclear device took place on October 31, 1952. The Soviets, in response to the test, increased their efforts to develop the superbomb. The test stimulated them to more intensive work on the mechanism behind the device's very high yield, and analysis of the test's fallout aided in discovering that mechanism.[54]

IV. THIRD POWER RESPONSE TO NUCLEAR WEAPONS

The Soviet-American competition in nuclear weapons development represented the most significant example of stimulus and response to technological innovation embodied in the bomb. Indeed, the advent of the atomic age forced all nations to reevaluate their strategic military position relative to those countries possessing nuclear weapons. Responses to the altered military balance varied from state to state according to its political position, technological expertise, and perceived military necessity.

In the years immediately following the war, Britain faced many difficult choices relating to the American monopoly of the atomic bomb. Britain had been, as historian Margaret Gowing argues, the "midwife" of the atomic bomb.[55] Without British scientific research in the early years of the war, the bomb would not have been available to the United States in 1945. Britain did not, however, have the resources to develop the atomic bomb alone during the war, and, once the Manhattan Project was under way, Britain became a decidedly junior partner in the Anglo-American nuclear relationship. British scientists had worked at Los Alamos and were knowledgeable about many, though not all, of the processes that went into the development of the bomb.

Nevertheless, the Manhattan Project was an American enterprise, and it was the United States, and not Great Britain, which possessed the bomb at war's end. Even though Britain and the United States were allies and Britain had little to fear from the American bomb, the basis for continued scientific nuclear interchange between the two nations in the atomic field was uncertain.[56]

The British response to this somewhat ambiguous position in relation to the American monopoly took two forms. First, Britain resorted to negotiations. The British negotiating position consisted of two basic objectives. On the one hand, the British pressed for international control of atomic weaponry; on the other, they sought to make their own atomic position as strong as possible by cementing a nuclear link with the United States. In November 1945, British Prime Minister Clement Attlee traveled to Washington seeking American support of both objectives. As a result, the two allies declared that the United Nations should set up a commission to make proposals for controlling atomic energy, and "that there should be full and effective co-operation in the field of atomic energy between the United States [and] the United Kingdom."[57]

Within a year, British hopes of meeting either negotiating objective had been effectively dashed. On the question of international controls, the British grew increasingly apprehensive that international authority would hamper Britain's own development of atomic energy and perhaps compromise British security. British support for the Baruch Plan was therefore only lukewarm, and they totally rejected the Gromyko Plan. Moreover, the United States grew increasingly disinterested in Anglo-American cooperation. In the spring of 1946, Britain requested American assistance in building a large-scale pile to produce plutonium. The United States deferred. When Attlee made reference to the November 1945 statement on cooperation, Truman wrote back that "full and effective co-operation" applied only to the field of basic scientific information. Ironically, given Britain's early enthusiasm for international control, the United States claimed that closer cooperation between the two nations should be avoided because it might compromise the discussions on control of the atomic bomb at the United Nations. Whatever cooperative spirit remained between the two nations in the atomic field at this point was stilled by the strict antidisclosure provisions of The Atomic Energy Act of 1946.[58]

The second British response to the American monopoly was to begin the development of a British atomic weapon. Such a policy, as Gowing notes, was "largely the instinctive response of a country which had been a great world power and believed itself to be one still, and which had the knowledge and industrial resources to develop what was manifestly the new passport to first-class military, and possibly industrial, rank."[59] During the war years, nearly all the British scientists and statesmen connected with the nuclear field assumed that Britain would develop weapons in the postwar years. The British laid the groundwork for developing an atomic capacity by approving a nuclear research center in early fall of 1945 and six months later deciding to build a plutonium production pile. The British Government, however, refused to state whether the plutonium would be used for bombs. Officials said only that they were awaiting the outcome of discussions to establish international control. Nevertheless, as it became clear that hopes for international control had been thwarted, a ministerial meeting in January 1947 confirmed what had been assumed all along: the British would develop an atomic bomb.[60]

Following World War II only Britain and the Soviet Union possessed the technological and economic capability to begin full-scale development of the bomb. The vast majority of states could do little but take notice of the American technological accomplishment, reevaluate their own military position, and perhaps make some contribution to negotiating international control of the new technology. Few states felt the compelling need to possess atomic weapons.

As relations chilled between East and West and the Cold War emerged, concern mounted over a perceived Soviet political and military threat. The North Atlantic Treaty Organization (NATO) was formed in 1949, before the Soviet Union tested its first atomic device, as a response to the Soviet threat and as an attempt to bring Western Europe closer to the United States. The military threat envisioned was a conventional one, and the treaty declared that "an armed attack against one or more of them [the members of NATO] in Europe or North America shall be considered an attack against them all."[61] Secretary of State Dean Acheson, in the treaty hearings before Congress, stated that the United States had no intentions of sending troops to shore up European defenses. For the United States, the immediate price of the NATO commitment was financial, and in July 1949 Truman asked Congress for $1.5 billion for European military aid. A cost-conscious House balked, but when Truman announced the Soviet atomic test in September, the aid bill sailed through in six days.[62]

Soviet possession of the bomb had an immediate impact. "This is now a different world," declared Senator Arthur Vandenberg.[63] As Leo Szilard explained, "The Russians can affect the political attitude of Western Europeans just by threatening to bomb them."[64] From the first, American nuclear weapons were an implicit part of NATO strategy, and in the 1950s, as the Soviets' nuclear capability increased, the Europeans put increasing reliance on an American alliance that provided them with a "nuclear umbrella." In September 1950, the United States, in response to the increased global threat brought on by the Korean War, placed four divisions of troops in Europe. The American strategy was that they would serve as a "tripwire." Any Soviet attack upon a NATO command containing American troops would automatically trip a nuclear response from the United States.[65]

NATO members, with the exception of Britain and France, eschewed a unilateral approach to their nuclear problem and relied on the multilateral framework based on the American nuclear arsenal. As a consequence, most NATO members expressed no interest in becoming individual nuclear powers. But with major NATO powers, such as Italy and West Germany, the pressure to develop a nuclear capability would have been much greater without the alliance.[66]

For France, however, the nuclear umbrella provided by the United States was not sufficient. By the mid-1950s, the French military were warning their government that as Soviet capabilities for inflicting nuclear retaliation on the United States grew, the American guarantee to defend Europe would inevitably weaken. NATO and the presence of American forces in Europe would no longer provide an adequate fulfillment of French security requirements. France therefore initiated a program to develop its own nuclear force. By 1958 the decision was made to conduct a nuclear test in early 1960.[67]

The United States was not the only superpower, however, having difficulties keeping its allies content beneath its nuclear umbrella. The Communist Chinese also wanted a nuclear capability of their own in the 1950s, and they attempted to attain such a capability by negotiating with the Soviets for nuclear assistance. In October 1957, the Soviets, in return for Chinese support for Soviet policy in Eastern Europe following the Hungarian uprising, apparently agreed to aid China in the development of nuclear weapons and even, according to the Chinese, pledged to deliver to China a sample atom bomb. But the Soviets had second thoughts, and by the early 1960s it was clear that the decision to aid China was, in the words of the historian Adam Ulam, "the most bitterly regretted Soviet policy since World War II."[68] The Soviets attempted to convince the Chinese that they had no need for nuclear weapons since they already had the protection of the Soviet Union. As late as 1963 the Soviets argued that development of nuclear weapons was not in China's best interest:

> China is as yet unprepared to produce nuclear weapons in quantity. Even if the People's Republic of China were to produce two or three bombs, this would not solve the question for it either, but would bring about a great exhaustion of China's economy. . . . That is why the most reasonable policy for the People's Republic of China in present conditions. . . would be to devote its efforts to the development of the national economy . . . devoting them to improving the well-being of the Chinese people.[69]

China did develop nuclear weapons counter to Soviet desires, but the members of the Warsaw Pact were not able to exercise a similar independence. Finland and Japan also faced political constraints inhibiting the development of a nuclear capability.[70] But most states were technically, financially, and materially limited. They simply did not have the resources to develop independent weapons, and, as a consequence accepted, though not necessarily willingly, the existing military balance.

Sweden, on the other hand, possessed the capability to develop nuclear weapons, but deliberately chose neither to build nuclear weapons nor to join a protective alliance. In the mid-1950s Sweden was on a par with France in technical development in the nuclear field. But the Swedish parliament issued a series of bans, beginning in 1957, against research aimed at the development of a nuclear weapon. A final ban, adopted in 1968, formally prohibited a nuclear component for Swedish defense and for all weapons-related research. Possession of the bomb, it was argued, would not enhance Sweden's security but, rather, make Sweden a target of other nuclear powers.[71]

V. THE AGE OF SCIENTIFIC TECHNOLOGY

World War II, according to the historian Alex Roland, was a conflict of industrial attrition. Yet, the war heralded a revolution in attitudes toward technological innovation. It created the predominate assumption that the quality of military technology, and not the quantity of industrial production, would be the prime determinant of success in warfare. The atomic bomb, combined with the other technical developments of the war, convinced political and military leaders alike that science and technology, research and development, would likely be the decisive factors in the military balance of power. Simply put, the best, not the most, weapons would determine the victor. Thus occurred a transition in emphasis from industrial technology to scientific technology. As a result, new technological weapons became eagerly sought after, as well as greatly feared should an adversary develop them first.[72]

By war's end, the American military agreed that technological innovation would result in better and more effective weapons. The journal Army Ordnance noted in the fall of 1944 that the maintenance of military superiority in peacetime would require "the marshalling of the best scientific brainpower of our country . . . from our great private research laboratories . . . educational institutions and . . . technical and scientific societies."[73] In the immediate post-war years the military services developed large "intramural" programs in which research was conducted at laboratories operated directly by each service. But "extramural" research -- civilian scientists and institutions conducting research under contract -- soon became far more extensive. Research and development expenditures rose steadily from less than $1 billion in 1947 to almost $6 billion in 1960.[74]

A corresponding expansion of military research and development took place in the Soviet Union. By the summer of 1946 major programs had been launched for developing nuclear weapons, long-range rockets, radar, and jet propulsion. The Soviets exercised tight control over these weapons development programs, which had first claim on scarce resources. In the atomic field, for example, a special government department managed the nuclear program, and the secret police had a department for atomic energy. Stalin took a direct and personal interest in all of the research and development programs, ensuring that they were assigned the country's best scientists and engineers.[75]

The object of this greatly expanded peacetime research and development activity was, in Roland's words, "to refight the last war with nuclear weapons."[76] One plane, one bomb, and the city of Hiroshima had had a revolutionary effect on strategic warfare. Certainly in the late 1940s the Soviet Army was not made obsolete by the American bomb, especially considering the relative scarcity of the bomb in the American arsenal.[77] But in the 1950s, as the nuclear arsenals multiplied on both sides, and as thermonuclear weapons exponentially increased nuclear destructiveness, the role of nuclear weapons in a total war became clear. Both sides knew -- more or less -- what the bomb would do and how to use it. Qualitative improvements in the bomb continued and stockpiles endlessly increased. Refinements of nuclear weapons reached a point where destructive yield was only limited by the ability to deliver the bomb to its target. Moreover, the number of nuclear bombs or war heads possessed by each of the superpowers became so large that quantitative increase in the number of devices in the nuclear arsenal, by itself, did little to alter the military balance. Nuclear weapons thus became the strategic given in the arms race between the two superpowers. In the past thirty years, the strategic balance of power has been threatened not by nuclear weapons but by innovative technology in the field of delivery systems and defense against delivery systems.[78]

Historians Bernard and Fawn Brodie have observed that the "marriage of nuclear weapons to missiles of all sizes . . . has meant a military revolution distinctive from and almost comparable to the revolution introduced by the nuclear weapons themselves."[79] Missiles have, indeed, played a role in most of the major technological innovations that have been applied to weapons systems since the first intercontinental ballistic missiles (ICBMs). Polaris submarines, antiballistic missile systems (ABMs), multiple, independently targetable re-entry vehicles (MIRVs), cruise missiles, silo-busting missiles, MX basing modes, and the Strategic Defense Initiative (SDI) have all been centered on missile delivery or missile defense. As each of these technologically-innovative weapons systems went through the process of development by one of the superpowers, they elicited responses similar, in part or in whole, to the historic responses of the Soviet Union to the American monopoly of the atomic bomb.

In most cases American development has stimulated Soviet response. The initial development of the ICBM, on the other hand, was a situation largely of Soviet stimulus and American response. Although Soviet interest in rocketry predated World War II, the appearance of the German V-1 and V-2 rockets in 1944 spurred Soviet activity. At the close of the war, the Soviets gained much knowledge from German rocket technology, and, unlike the United States, the Soviet Union gave high priority to rocket development. As Stalin reportedly said in an April 1947 meeting at the Kremlin,

> Do you realize the tremendous strategic importance of machines of this sort [ICBMs]? They could be an effective straitjacket for that noisy shopkeeper Harry Truman. We must go ahead with it comrades. The problem of the creation of transatlantic rockets is of extreme importance to us.[80]

The result of Soviet efforts was the launching of Sputnik in October 1957, which demonstrated in a dramatic way that the United States could now be attacked by Soviet nuclear weapons delivered by ICBMs. Americans suddenly realized that the Soviets had surpassed the United States in missile development. The British ambassador reported that Sputnik had stunned officials in Washington: "The Russian success in launching the satellite has been something equivalent to Pearl Harbor. The American cocksureness is shaken."[81] The Eisenhower Administration responded by accelerating the American ballistic missile program and ordering the dispersal of Strategic Air Command bombers. In January 1958, the United States successfully launched its first satellite, and in July created the National Aeronautics and Space Administration. In addition, Americans feared that Sputnik meant that Soviet education was superior, and, as a result, federal aid was offered to educational programs in science and math in the name of national defense.[82]

Sputnik became an issue in American politics. The Democrats charged that Eisenhower had paid insufficient attention to the national defense and had allowed a "missile gap" to develop. In the 1960 presidential campaign, John F. Kennedy stated that the Eisenhower Administration was losing the Cold War by tolerating the missile gap. Eisenhower, relying on U-2 flights that began in 1956, knew that this claim was nonsense. There was virtually no ICBM threat. The Soviets had decided to give priority to deployment of medium-range ballistic missiles (MRBMs). Since the first-generation Soviet ICBM was not really suitable as a military weapon because of its highly unstable, non-storable propellant, the Soviets decided to wait for more advanced and reliable second- and third-generation models of the ICBM. Thus, by 1961, the Soviets had deployed only four ICBMs.[83]

That same year the United States possessed 63 ICBMs, and the Kennedy Administration accelerated the missile building program so that by 1963 the United States possessed

424. In reality, the missile gap greatly favored the United States and forced the Soviets to respond to the military imbalance. By the fall of 1962 the Soviets attempted, as the historian Walter McDougall has noted, "to close the reverse missile gap" by placing MRBMs in Cuba.[84] The result was a severe setback for the Soviets when the United States forced the withdrawal of the missiles. Following the Cuban missile crisis the Soviet Union entered the ICBM arms race on a massive scale. As one Soviet leader remarked: "Never will we be caught like this again."[85]

By the late 1960s the Soviets had acquired quantitative, if not qualitative, strategic parity with the United States in ICBMs. But throughout most of the decade, while the strategic imbalance remained, the Soviets devoted substantial effort to strategic air defense, civil defense, and the development of an ABM. Soviet research on ballistic missile defense began shortly after World War II, and by the mid-1960s the Soviets began to build an ABM system around Moscow. At the same time, the United States started to develop an ABM system. To counter an effective Soviet ABM system, the United States began to develop MIRVs as well.[86]

The Soviet Union, having achieved parity in ICBMs, feared that American technological innovation, especially in the field of ballistic missile defense, threatened the balance of power. At the Strategic Arms Limitation Talks (SALT), conducted from 1969 to 1972, the Soviets made clear their desire to limit ABM deployment, geographically and numerically, because the United States had a technological superiority in ABM development. Since the Soviet objective of limiting ABM deployment accorded with the American desire to avoid an arms race, an agreement was successfully negotiated.[87]

The Soviets also expressed a willingness to negotiate MIRVs at SALT, calling for a ban on production and deployment but not testing. The United States, in contrast, proposed a ban on MIRV testing and deployment, but not on MIRV production. The logic behind the two proposals was simple: The United States had a fully-tested system ready for deployment and the Soviet Union did not. Forbid production and deployment but not testing, and the Soviet Union would be able to catch up to the American position of having capability to deploy. Forbid testing and deployment but not production, and the American advantage in having a tested system would be frozen in place. Neither superpower expressed much interest in negotiating further, and the MIRVs issue fell by the wayside at SALT. The Soviets apparently were willing to accept their current disadvantage because in the long term they had the greater potential for MIRVs due to their larger ICBM throw-weight.[88]

The Soviets viewed the ABM Treaty as the most significant achievement of SALT. The significance of the treaty, according to David Holloway, is that it "codified a situation in which the Soviet Union and the United States were equally vulnerable to a retaliatory strike, no matter who struck first."[89] Holloway also emphasizes that the Soviets view the current Strategic Defense Initiative as an American attempt to abrogate this mutual vulnerability. Listing the Soviet options as to how they might respond, he notes that they could: 1) develop their own SDI system, 2) upgrade their offensive missile capability to overwhelm SDI or develop and deploy anti-satellite weapons to attack and destroy SDI, or 3) attempt to stop or slow down SDI through arm-control negotiations.[90] In other words, in response to a potential American technological breakthrough, the Soviets could respond by obtaining similar technology, negating the technological advantage, or negotiating. Historically, the options are the same kinds of responses the Soviets made to the American monopoly of the atomic bomb, and that have been present in the Soviet-American arms race over the past three decades.

CONCLUSION

In the nineteenth and early twentieth centuries, technological innovation played a secondary role in strategic military thinking during peacetime. But with the Second World War and the advent of nuclear weapons, technological innovation became a prime determinant in the strategic military balance. Consequently, most of the historical examples of a nation responding to a technological breakthrough of a potential adversary occur in the post-World War II period. Only in the development of naval technology during the nineteenth century was there an analogous situation to the contemporary period.

Although alternate responses, such as the launching of a preemptive strike, are not inconceivable, the historical record reveals that states, when they perceive that a technological innovation threatens to alter the military balance of power, respond in one or more of the four following ways:

1) <u>Nations make strenuous efforts to obtain, through espionage, purchase, or independent development, the technology for themselves.</u>

During the nineteenth century, innovative technology was, for the most part, available on the marketplace. Thus, Chile, a second- or third-rate power, was able in 1882 to purchase from a British firm a cruiser that was superior to any comparable ship in the British fleet. By the close of the century, however, technology increasingly was viewed as a national resource, and, as a result, secrecy and restrictions on technology transfer became more common. In 1906, for example, Britain commissioned the Dreadnought, which was the first major warship built in secrecy. All other major navies, forced to wait and see what the British would do, responded by developing similar warships of their own.

The development of the atomic bomb provides an additional example of this response. In 1939 the United States made the decision to begin research on the bomb largely in response to concern that Germany was performing similar research. The Soviet Union, in the 1940s, reacted to the United States' monopoly of the atomic bomb by developing and testing their own atomic bomb. The Soviets accomplished this development through espionage and independent development.

During the Cold War, the two superpowers have tended to imitate the technological innovations of each other. In

1957 the Soviet Union launched Sputnik, giving evidence of ICBM capability. The United States responded by substantially increasing the pace of its own development.

2) Nations attempt to negate the technological advantage either by developing innovative alternative technologies or by forming alliances to counterbalance the technologically superior state.

The mid-1850s witnessed the development of innovative technologies in the areas of armament and armor. In 1859 France launched the Gloire, the first seagoing ironclad, in response to new rifled ordnance. The Gloire's armor was resistant to anything that existing British warships could bring against it. The British responded by developing armament that could smash through the ironclad's armor.

Since the development of the ICBM, technological innovation has focused on ballistic missile defense and methods of countering that defense. Thus, in the 1960s, the Soviet Union developed an ABM system to defend against ICBMs. The United States, in the 1960s, developed MIRVs to counter ABMs.

Moreover, alliances have become useful for some states as a response because the weapons of modern strategic warfare require advanced technological capability and tremendous financial resources. NATO was originally formed to counter a conventional military threat from the Soviet Union. But as the Soviet nuclear threat increased in the 1950s, the United States, through NATO, provided a "nuclear umbrella" for other members. Nations that otherwise might have acquired their own nuclear weapons, such as West Germany and Italy, have counterbalanced the Soviet nuclear threat through membership in NATO.

3) Nations seek to negotiate with the state that has achieved the advanced technology in order to restore the military balance or to prevent the full implementation of the technology in a weapons system.

Prior to World War II, arms negotiations were directed at controlling quantities of weapons and limiting dimensions of weapons. Since 1945, the control of technologies has also entered the negotiating equation. In 1946 the United States proposed the Baruch Plan for international control of atomic weaponry. The Soviet Union, in response to the American monopoly of the bomb, offered a counterplan envisaging an international convention that prohibited the production or use of atomic weapons and required the destruction of existing ones.

At the SALT I negotiations (1969-1972), the Soviet Union favored limiting ABM deployment because the United States had a technological superiority in ABM development. The Soviet Union also proposed a halt to the deployment, but not the testing, of MIRVs because the United States had a fully-tested system and the Soviet Union did not. The United States favored a ban on testing and deployment which, in effect, would have frozen the American advantage in place.

Negotiations have also been used by one state to obtain a technological innovation from another. In the late 1950s, for example, China entered into negotiations with the Soviet Union in an effort to obtain the technology necessary for building nuclear weapons.

4) <u>Nations choose to do nothing if one of the above responses is not within their capabilities or if they are willing to accept the altered military-technological balance of power.</u>

Since 1945, the vast majority of nations have lacked the technological, financial, and material resources to develop nuclear weapons and sophisticated delivery systems. Other nations, such as Finland, Japan, and East European members of the Warsaw Pact faced political constraints which prevented their acquisition of strategic weaponry.

In contrast, Sweden, in the 1950s, possessed the technological capabilities to develop atomic weapons but made the deliberate decision not to pursue development and deployment.

Since World War II, the two superpowers have, at various times, used one or more of the first three responses listed above, but neither superpower has had the luxury, as have lesser powers, of doing nothing when faced with the possibility of technological breakthrough by the other superpower. To do nothing has posed excessive risks which neither superpower has been willing to take, and, with a true technological breakthrough that alters the military balance of power, doing nothing would effectively remove the state from superpower status.

END NOTES

1. Michael Howard, War in European History (London: Oxford University Press, 1976), pp. 30, 101.

2. Ibid., p. 81. See also William H. McNeill, The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000 (Chicago: University of Chicago Press, 1982), pp.185-222.

3. McNeill, The Pursuit of Power, pp.231-232, 235-236, 242; Howard, War in European History, pp. 102-103.

4. McNeill, The Pursuit of Power, p. 253; Howard, War in European History, pp. 102-106.

5. McNeill, The Pursuit of Power, p. 255.

6. Howard, War in European History, p. 122.

7. Bernard Brodie, Sea Power in the Machine Age (Princeton: Princeton University Press, 1942), pp. 223-224; Donald C. Swain, "Organization of Military Research," in Technology in Western Civilization, eds. Melvin Kranzberg and Carroll W. Pursell, Jr. (New York: Oxford University Press, 1967), pp. 535-536.

8. McNeill, The Pursuit of Power, pp. 227-228; Brodie, Sea Power in the Machine Age, p. 12.

9. Brodie, Sea Power in the Machine Age, pp. 56, 440; Karl Lautenschlager, "Technology and the Evolution of Naval Warfare," International Security (Fall 1983): 7-8.

10. Brodie, Sea Power in the Machine Age, pp. 24-25, 57; Lautenschlager, "Technology and the Foundation of Naval Warfare," pp. 7-8.

11. Brodie, Sea Power in the Machine Age, pp. 47-49.

12. Ibid., pp. 51-54.

13. Ibid., pp. 56-68.

14. Ibid., pp. 67-69; McNeill, The Pursuit of Power, p. 228. In 1846, when France began its major naval program, the

British naval appropriations exceeded those of the French by a ratio of 8 to 5. By 1849 French enthusiasm for a costly arms race had greatly waned, and France offered to make "almost any reduction" provided the British did so "upon the same relative scale." Although the British were largely unresponsive, between 1848 and 1851, each successive budget brought reductions in French naval expenditures. Brodie, Sea Power in the Machine Age, pp. 48, 52, 68.

15. Brodie, Sea Power in the Machine Age, pp. 75-76; Lautenschlager, "Technology and the Evolution of Naval Warfare," pp. 10-11; McNeill, The Pursuit of Power, p. 239; quoted in James Phinney Baxter III, The Introduction of the Ironclad Warship (Cambridge: Harvard University Press, 1933), pp. 117, 123.

16. Brodie, Sea Power in the Machine Age, p. 195; Baxter, Introduction of the Ironclad, p. 141.

17. Brodie, Sea Power in the Machine Age, pp. 66, 242; McNeill, The Pursuit of Power, pp. 291-292. Patent-sharing agreements existed between companies in different countries. The situation indicates that at this time private firms did not perceive that negotiated commercial agreements might compromise national security. Patent-sharing agreements between British arms manufacturers and the Krupp arms firm of Germany, for example, continued to be honored even during the hostilities of World War I. McNeill, The Pursuit of Power, p. 292.

18. McNeill, The Pursuit of Power, pp. 241, 262-263.

19. McNeill, The Pursuit of Power, pp. 262, 278-279, 289.

20. Ibid., p. 281; Lautenschlager, "Technology and the Evolution of Naval Warfare," pp. 10-11.

21. Quoted in Arthur J. Marder, The Anatomy of British Sea Power (New York: Alfred A. Knopf, 1940), p. 538.

22. Ibid., pp. 535-538; Brodie, The Pursuit of Power, p. 242.

23. Marder, Anatomy of British Sea Power, p. 538; Holger H. Herwig, Luxury Fleet: The Imperial German Navy 1888-1918 (London: George Allen & Unwin, 1980), pp. 54-59.

24. Brodie, Sea Power in the Machine Age, p. 242. Germany's Admiral Alfred Tirpitz was quick to employ the methods of

secrecy in 1907. As the historian Holger Herwig notes, "With regard to Britain, he urged the greatest secrecy in order to camouflage his plans. Ceilings for battleships of 47 million GM and for battle-cruisers of 44 million GM were to be kept confidential; technical improvements, which could easily be detected in higher prices, were to be hidden by releasing only flat-rate figures for construction; launching and commissioning dates were to be regarded as state secrets; and the Imperial Treasury was asked not to release statistics concerning the increase in naval personnel." Herwig, Luxury Fleet, p. 63.

25. Quoted in Brodie, Sea Power in the Machine Age, p. 287.

26. Ibid., p. 290.

27. Ibid., pp. 295-298; Herwig, Luxury Fleet, pp. 86-88. Tirpitz considered the battleship as the optimum naval weapon, and in response to novel weapons such as the submarine, he refused to create what he termed a "museum of experiments." Herwig, Luxury Fleet, p. 86.

28. Brodie, Sea Power in the Machine Age, pp. 302-303. Before 1914 it was axiomatic that the "guerre de course" could not be, as Alfred Thayer Mahan said, "by itself alone decisive of great issues." Ibid., p. 331.

29. Ibid., pp. 316-317, 325-326.

30. Herwig, Luxury Fleet, pp. 226-227; Brodie, Sea Power in the Machine Age, pp. 333-335.

31. Bernard and Fawn M. Brodie, From Crossbow to H-Bomb (Bloomington: Indiana University Press, 1973), pp. 176-177; Irving B. Holley, Ideas and Weapons (New Haven: Yale University Press, 1953), pp. 26-27, 30.

32. Holley, Ideas and Weapons, pp. 29-33; Alex Roland, "Science and War," Osiris, 2nd ser., 1 (1985): 262-263.

33. McNeill, The Pursuit of Power, pp. 331-335; Edward L. Katzenbach, Jr., "The Mechanization of War, 1880-1919," in Technology in Western Civilization, eds. Kranzberg and Pursell Jr., p. 553; Roland, "Science and War,"in Osiris: 262-263.

34. Howard, War in European History, pp. 127-130.

35. Roland, "Science and War," pp. 263-264; McNeill, The

Pursuit of Power, p. 357; Swain, "Organization of Military Research," pp. 538-543.

36. Brodie and Brodie, _From Crossbow to H-bomb_, p. 201. Had the Germans mobilized their scientific resources earlier, the war might have had significantly different results. As Michael Howard notes, "A little more concentration by the Germans on the development of jet aircraft might have changed the course of the air war. Had they devoted more resources to missile technology they might have produced rocket weapons which would have laid central London to waste and made the allied landings in Normandy impossible, and if their nuclear research had taken a rather different turn and received greater political backing, they might have developed nuclear weapons. . . ." Howard, _War in European History_, p. 135.

37. Roland, "Science and War," p. 265; McNeill, _The Pursuit of Power_, p. 358.

38. Richard G. Hewlett and Oscar E. Anderson, _The New World, 1939-1946: A History of the Atomic Energy Commission_ (University Park: Pennsylvania State University Press, 1962), pp. 10-17; Gerard H. Clarfield and William H. Wiecek, _Nuclear America: Military and Civilian Nuclear Power in the United States, 1940-1980_ (New York: Harper & Row, 1984), pp. 17-20; letter from Albert Einstein to F. D. Roosevelt, August 2, 1939 in _The American Atom: A Documentary History of Nuclear Policies from the Discovery of Fission to the Present 1939-1984_, Robert C. Williams and Philip L. Cantelon, eds. (Philadelphia: University of Pennsylvania Press, 1984), pp. 12-14.

39. Hewlett and Anderson, _The New World_, pp. 19-20.

40. Ibid., pp. 19-20.

41. Clarfield and Wiecek, _Nuclear America_, pp. 20-52; Hewlett and Anderson, _The New World_, pp. 20-407.

42. Quoted in David Holloway, _The Soviet Union and the Arms Race_ (New York: Yale University Press, 1983), p. 20. In November 1945 Molotov said that the Soviet Union "must equal the achievements of contemporary world technology. . . . We will have atomic energy and much else." Ibid., p. 27.

43. Ibid., p. 20.

44. Gregg Herken, _The Winning Weapon: The Atomic Bomb in the_

Cold War 1945-1950 (New York: Vintage Books, 1981), p. 20; Adam B. Ulam, The Rivals: America and Russia Since World War II (New York: Praeger, 1965), pp. 76-77; quoted in Holloway, The Soviet Union and the Arms Race, p. 16.

45. Holloway, The Soviet Union and the Arms Race, pp. 15-20; 22-23.

46. Ibid., p. 27. The great emphasis the Soviets placed on developing their own nuclear weapons belies Stalin's seeming lack of concern. Yet even American strategists were not entirely convinced that the possession of atomic weapons automatically conveyed military supremacy. In 1949, for example, air force spokesmen rejected the "illusory hope" that atomic bombs alone would be sufficient to win the next war. The air force went no further than the modest claim "that the engagement of surface forces will take place with much greater assurance of success, and much fewer casualties... if an immediate full-scale atomic offensive is launched against the heart of the enemy's war-making power." Clarfield and Wiecek, Nuclear America, p. 87.

47. Clarfield and Wiecek, Nuclear America, p. 87; Holloway, The Soviet Union and the Arms Race, p. 27.

48. Adam B. Ulam, Expansion and Coexistence (New York: Praeger, 1974), pp. 416-417. It is possible that the Soviets had such low regard for American diplomatic skill that they believed that negotiations offered opportunity for substantial gain. Ibid., p. 40.

49. Ibid., pp. 415-416. For a more detailed discussion of Soviet-American negotiations in the immediate postwar period, see Herken, The Winning Weapon, pp. 60-94 and Hewlett and Anderson, The New World, pp. 455-481, 531-619.

50. It was called a superbomb because it was just that: a quantum leap in the explosive output over that of an atomic bomb. In early discussions of the superbomb, it was estimated that explosive energy yields would be about one thousand times as great as those of atomic bombs. Early atomic weapons had a yield of approximately twenty kilotons of TNT equivalent. The first hydrogen bombs were in the fifteen megaton range, and the largest superbomb ever exploded was in 1961 by the Soviet Union, with a yield of nearly sixty megatons. Herbert York, The Advisors: Oppenheimer, Teller, and the Superbomb (San Francisco: W.H. Freeman and Company, 1975), p. 45; Williams and Cantelon, The American Atom, pp. 114-115.

51. Williams and Cantelon, The American Atom, pp. 132-133; York, The Advisors, pp. 20-28; David Holloway, "Soviet Thermonuclear Development," International Security (Winter, 1979/80): 192-193.

52. York, The Advisors, pp. 41-74; quoted in Richard G. Hewlett and Francis Duncan, Atomic Shield 1947-1952: A History of the United States Atomic Energy Commission vol. II. (Washington, D.C.: U.S. Atomic Energy Commission, 1972), p. 394.

53. Lewis Strauss to Harry Truman, November 25, 1949, in Williams and Cantelon, The American Atom, p. 129. Those who opposed the development of the superbomb were not unaware of the possibility that the Soviets might develop the weapon even if the United States did not. As the General Advisory Committee noted, "It is by no means certain that the weapon can be developed at all and by no means certain that the Russians will produce one within a decade. To the argument that the Russians may succeed in developing this weapon, we would reply that our undertaking it will not prove a deterrent to them. Should they use the weapon against us, reprisals by our large stock of atomic bombs would be comparably effective to the use of a super." USAEC General Advisory Committee Report on the Super, October 30, 1949, in Ibid., p. 126.

54. York, The Advisors, pp. 75-83; Holloway, "Soviet Thermonuclear Dvelopment," pp. 195-196. A Soviet source credits the American test with intensifying the Soviet development. After the test, "those taking part in the creation of the terrible new weapon increased the tempo of work. Alongside the design work, experiments are conducted to investigate different variants." Quoted in Ibid., "Soviet Thermonuclear Development," pp. 195-196.

55. Margaret Gowing, Independence and Deterrence: Britain and Atomic Energy, 1945-1952 (London: MacMillan, 1964), p.1.

56. Ibid., pp. 2-13; Hewlett and Anderson, The New World, p. 457.

57. Hewlett and Anderson, The New World, pp. 461-469;quoted in Gowing, Britain and Atomic Energy, p. 76.

58. Gowing, Britain and Atomic Energy, pp. 87-115; Hewlett and Anderson, The New World, pp. 477-481.

59. Gowing, Britain and Atomic Energy, p. 63.

60. Ibid., pp. 160-185.

61. Walter LaFeber, America, Russia, and the Cold War, 1945-1975, 3rd ed. (New York: John Wiley and Sons, Inc., 1976), pp. 83-86; Robert Hunter, Security in Europe (Bloomington: Indiana University Press, 1969.), p. 229.

62. LaFeber, America, Russia, and the Cold War, pp. 85-86.

63. Quoted in Ibid., p. 86.

64. Quoted in Ibid., p. 86.

65. Hunter, Security in Europe, pp. 85-86; LaFeber, America and Russia, pp. 112, 128-129.

66. Timothy W. Stanley, Nato in Transition: The Future of the Atlantic Alliance (New York: Praeger, 1965), pp. 157-198.

67. Michael M. Harrison, The Reluctant Ally: France and Atlantic Security (Baltimore: Johns Hopkins University Press, 1981), pp. 36-37. Status as a major world power also played a role in the decision to develop nuclear weapons. As Charles de Gaulle noted, "One cannot conceive of a national role without disposing independently of modern military power." Quoted in Stanley, Nato in Transition, p. 157.

68. Ulam, Expansion and Coexistence, pp. 599, 611. According to the Chinese, the Soviets reneged on the agreement only two years after it was signed. "As far back as June 20, 1959... the Soviet government unilaterally tore up the agreement on new technology for national defense concluded between China and the Soviet Union on October 15, 1957, and refused to provide China with a sample of an atomic bomb and technical data concerning its manufacture." Quoted in William E. Griffith, The Sino-Soviet Rift (Cambridge: Harvard University Press, 1964), p. 351.

69. Ulam, Expansion and Coexistence, p. 662; quoted in Griffith, The Sino-Soviet Rift, p. 363.

70. Hunter, Security in Europe, p. 96; Ulam, Expansion and Coexistence, pp. 610-611, 746-747.

71. "Sweden Admits Nuclear Test, Says It Will Not Build Bomb," The Washington Post, 27 April 1985, sec. 1, p. A1; "Swedish Officials Defend A-Research," The Washington Post, 5 May 1985, sec. 1, p. A1. 72. Merritt Roe Smith, Military Enterprise and Technological Change: Perspectives on the American Experience (Cambridge: The MIT Press, 1985), p. 367; Roland, "Science and War," p. 266; Walter A. McDougall, The Heavens and the Earth: A Political History of the Space Age (New York: Basic Books, Inc., 1960), pp. 78-79.

73. Roland, "Science and War," p. 266; quoted in Daniel J. Kevles, The Physicists (New York: Vintage Books, 1979), p. 352.

74. Swain, "Organization of Military Research," p. 544.

75. Holloway, The Soviet Union and the Arms Race, pp. 21-22. The priority given to military research and development is indicated by the impact the new weapons programs had on the Soviet five year plan adopted in March 1946. The then minister of finance noted that finding resources for the plan proved more difficult than anticipated because the drop in defense spending was not as great as expected, and because "significant resources" were required for the development of military technology. The new five year plan called for an annual research and development budget four times higher than the record figure allotted, but never implemented, in 1941. Ibid., p. 21; McDougall, The Heavens and the Earth, p. 51.

76. Roland, "Science and War," p. 266.

77. The historian Walter A. McDougall notes that the United States in the immediate postwar years possessed neither a significant atomic arsenal nor a strategy of how to use it. "The atomic bomb had not found a place in U.S. strategy. War plan °Pincher' (June 1946) viewed the bomb as a distinct advantage, but could not integrate its use due to secrecy concerning its numbers and destructive force. The AAF plan °Makefast' made no allowance at all for atomic weapons. In any event, the military had little notion of how bombs could possibly prevent a Soviet takeover of Western Europe. . . . Even if an air-atomic strike had been deemed a war-winning capability . . . there were only a dozen or so warheads in the arsenal [from] Febuary 1946 to April 1948." McDougall, The Heavens and the Earth, p. 93.

78. Brodie and Brodie, From Crossbow to H-bomb, pp.

261-265, 279, 293-294. This is not to say that the advent of tactical nuclear weapons has not had tremendous impact on military thinking, but the discussion of such tactical capabilities is beyond the scope of this study. It can also be argued that strategic thinking with regard to the use of nuclear weapons has been the subject of much debate and discussion over the past three decades. But as James Fallows notes, "What has not really changed since the fifties, despite appearances to the contrary, is the theory of how these weapons would be used and where they would be aimed." James Fallows, National Defense (New York: Random House, 1981), p. 143; see also Fred Kaplan, The Wizards of Armageddon (New York: Simon and Schuster, 1983).

79. Brodie and Brodie, From Crossbow to H-bomb, p. 261.

80. Quoted in Holloway, The Soviet Union and the Arms Race, pp. 65-66.

81. LaFeber, America, Russia, and the Cold War, p. 199; Holloway, The Soviet Union and the Arms Race, p. 66; quoted in Thomas G. Paterson, J. Garry Clifford, and Kenneth J. Hagan, American Foreign Policy: A History (Lexington, MA: D.C. Heath and Company, 1977), p. 495.

82. Paterson, Clifford, and Hagan, American Foreign Policy, pp. 494-495.

83. Ibid., pp. 494, 534; LaFeber, America, Russia, and the Cold War, p. 200; McDougall, Heavens and the Earth, pp. 250-251; Holloway, The Soviet Union and the Arms Race, pp. 66-67.

84. Paterson, Clifford, and Hagan, American Foreign Policy, p. 535; McDougall, Heavens and the Earth, p. 271.

85. Quoted in Paterson, Clifford, and Hagan, American Foreign Policy, p. 545. Holloway states that "it seems likely that the [Soviet ICBM] plan was altered in response to the Kennedy Administration's build-up of strategic forces. New decisions may have been taken in 1961, after the magnitude of the American programs had become clear. It is also possible that a major revision of the ICBM program took place in 1963, following the Cuban Missile Crisis." Holloway, The Soviet Union and the Arms Race, pp. 43-44.

86. Raymond L. Garthoff, Detente and Confrontation: American-Soviet Relations from Nixon to Reagan (Washington, D.C.: The Brookings Institution, 1985), p. 16; Raymond L.

Garthoff, "BMD and East-West Relations," in Ballistic Missile Defense, eds. Ashton B. Carter and David N. Schwartz (Washington, D.C.: The Brookings Institution, 1984), p. 291; and Sayre Stevens, "The Soviet BMD Program," in Ibid., pp. 189-204; Holloway, The Soviet Union and the Arms Race, pp. 44-46.

87. Holloway, The Soviet Union and the Arms Race, pp. 45-47; Garthoff, Detente and Confrontation, p. 133; Stevens, "The Soviet BMD Program," pp. 202-203.

88. Garthoff, Detente and Confrontation, pp. 137-140.

89. Holloway, The Soviet Union and the Arms Race, pp. 46-47; David Hollway, "The Strategic Defense Initiative and the Soviet Union," Deadalus (Summer 1985), p. 261.

90. Holloway, "The Strategic Defense Initiative and the Soviet Union," pp. 265-277.

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