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With A Bloody Union Jack On Top:

The First Generation British Atomic Deterrent

by

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ABSTRACT

Britain constructed an atomic deterrent to influence both the United States and Soviet Union. The process of research and development was both long and difficult. The atomic bomb, first tested in 1952, was a remarkable success. By comparison, the delivery device, the V-bomber, was a failure. While the aircraft produced were excellent, they were deployed too late in too few numbers to be effective in an independent role. Only as part of a larger offensive with the Strategic Air Command could they make a valuable contribution. However, the program's military failure was offset by its political success. Reopened atomic relations with the United States strengthened British security by providing London with the most modern nuclear weapons and delivery systems.

ACKNOWLEDGMENTS

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DEDICATION

This thesis is dedicated to the shepherd who, according to legend, discovered coffee. Without his extraordinary find, this thesis would never have been written.

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Introduction

> We've got to have this. . . . I don't mind for myself, but I don't want any other Foreign Secretary of this country to be talked to or at by a Secretary of State in the United States as I have just had in my discussions with Mr Byrnes. We have got to have this thing over here whatever it costs . . . We've got to have the bloody Union Jack on top of it.
>
> - Foreign Secretary Ernest Bevin, 1947[1]

Studies of Britain's position as a power after 1945 treat the decision to become the world's third nuclear state as one of London's most fundamental strategic choices in the postwar period. Such works, however, rarely treat the early British nuclear program as a whole, but rather as only one of its many parts. Some accounts view the program purely as part of British military policy, others simply as an aspect of foreign policy, and still more as a technological achievement. Each of these focuses is fundamental to the understanding of the deterrent, but in itself none tells the whole story. These accounts lead a reader to ask important questions, but then provide only partial answers to them. Only when the first generation atomic deterrent is examined as a whole can its nature and significance be fully understood.

The secondary literature which refers to this topic is often good and sometimes irreplaceable. In particular, several official histories are fundamental to any student. These works draw on many primary sources which are closed or have been destroyed and hence in some ways are the closest we can come to the primary documents. Scholars unanimously praise the value of Margaret Gowing's official histories. These volumes give a detailed and thoughtful account of the atomic energy program during and after the war.

They are, however, limited to the atomic bomb and energy projects as industrial, scientific, and technological matters. Gowing's political analysis is thorough, but limited to the roots of the programs rather than to their fruits. She has not analyzed the military effects of the atomic bomb, nor the delivery systems to which it was married. The latter task has been ably handled by another invaluable series of official histories on the postwar Bomber Command by Humphrey Wynn: The Bomber Role, a demi-official and unpublished study, and a published work derived from it, RAF Nuclear Deterrent Forces. These studies revolve around the development and especially the deployment of the V-bombers throughout their operational lifetime, as well as other R. A. F. nuclear projects. Their greatest strength is the depth of documentation in their narrative account, but Wynn makes little attempt to assess Bomber Command's effectiveness outside the realm of its own records. In any case, the official histories of Gowing and Wynn are fundamental to the study of the material and technical aspects of the British atomic deterrent, but each treats its topic in isolation from both the other and from broader operational and strategic issues.

The same technical topics have been examined by unofficial works, such as Brian Cathcart's Test of Greatness. Through a combination of primary and secondary sources, Cathcart produces a highly readable account of the bomb program. Where other descriptions are dry and occasionally confusing, Cathcart keeps the reader's attention with his flowing prose. The grace of this style, however, sometimes limits the depth of his analysis, and like Gowing, Cathcart discusses the bomb project without considering the other half of the deterrent—the medium bomber force. Another set of works, exemplified by Andrew Brookes' V-Force, focuses in detail on the bomb's delivery vehicle. These books are written by R. A. F. officers for aircraft enthusiasts. They incorporate fantastic technical detail about these aircraft and their equipment, at the expense of the political and strategic aspects of the project. The authors' personal experiences with and love of their subject shine through in all these books, but it tends to blind them to weaknesses in the aircrafts' combat potential. The development of atomic weapons, moreover, only plays a small role in these works.

The issue of Anglo-American relations during the early Cold War is the subject of many studies, a typical example being Great Britain and the United States: Special Relations since World War II by Robert Hathaway. These books are a good source for the political background of the alliance and for Anglo-American atomic collaboration. Given their wide topical and chronological scope, however, they do not focus too closely on any individual subject, nuclear weapons included, although of course their broad overview does put atomic relations in context. When these works address atomic issues, it is always in terms of Anglo-American relations—negotiations over exchange of information, British concern about potential employment of atomic weapons in Korea, the joint Skybolt project, and the like. They demonstrate that atomic weapons have at times played a pivotal role in Anglo-American diplomacy, but have never constituted the whole relationship. At the same time, such studies take much for granted about the technical side of the deterrent—they simply assume that it existed, without considering how far that was really the case. The same is true of the extensive literature dealing with general British foreign policy in the Cold War era, including such books as Elisabeth Barker's The British Between the Superpowers 1945-50. These works examine Britain's role in the formative years of the Cold War not simply as a member of the 'West' or an American satellite, but as a separate entity with genuine power, influence, and significance. This school illuminates London's political and economic position in the world during the time of the atomic bomb project, and the grand strategy which it fit into. They show the place of atomic weapons in the arsenal of a diplomatically influential but economically weak Britain caught between two superpowers.

A small number of strategic histories have addressed the issues which concern this thesis with unusual effect. R. N. Rosecrance's Defense of the Realm is typical of works of this school, which examine British defense more generally in the nuclear age. Chronologically, these books span from the end of World War II to the present, while they look at defense and atomic issues from economic and political perspectives. Many do emphasize nuclear topics, but often in a wider spectrum of issues including conventional forces.

Works like A. J. R. Groom's British Thinking About Nuclear Weapons and Andrew Pierre's Nuclear Politics provide more comprehensive looks at the British atomic program. Strategy, political debate, and Anglo-American relations figure prominently in these works, but the issue of the military effectiveness of the deterrent plays a smaller role.

Most valuable of the few strategic studies of the early program are Martin Navias' Nuclear Weapons and British Strategic Planning and Ian Clark and Nicholas J. Wheeler's The British Origins of Nuclear Strategy. The latter work, heavily based on primary documentation, provides insights into issues which other books ignore completely; the book places the atomic deterrent in the historical context of strategic bombing and emphasizes Britain's vulnerability to the new weapon. It accomplishes the authors' stated goal of "complementing the existing histories by focusing much more clearly upon the nature of British ideas about nuclear strategy."[2] They convincingly prove that the British atomic deterrent was intended to influence both the U. S. and U. S. S. R. Their discussion of the evolution of British targeting is especially compelling. Clark and Wheeler's study is an invaluable resource which has shaped the arguments of this paper.

While these books vary from good to excellent in quality, they do share flaws. Those written in the 1960s and 1970s concentrate on issues which were then of contemporary concern, such as Polaris, Chevaline, and Trident. Except for those books which consciously limit their focus to the early atomic program, the period of the 1940s and early 1950s is placed in the background. Books written before about 1980, moreover, were fundamentally limited in their access to the sources. Only recently have the primary documents needed to make a detailed study of the early atomic program become available, such as the 1952 Global Strategy Paper, which provides an important glimpse of early thinking on nuclear issues.

Above all, however, these works are concerned with atomic power, and much of their disparate analyses rest on judgments about Britain's status as one. Yet none of them have adequately addressed the issue of how effectively that deterrent worked, or could have worked, or whether it really existed. They have written about deterrence without studying the deterrent, about strategy without power. They have not treated this issue from a strategic perspective, nor have they integrated all parts of the topic in the context of the whole. Moreover, many of these books equate the deterrent with the bomb alone, entirely ignoring the delivery system. This shortcoming perpetuates the incorrect perception that the mere possession of an atomic bomb creates the means to deliver it and therefore the deterrent. Since the development of the British bomb itself was a remarkable success story, these assumptions lead many writers to misconstrue Britain's success as an atomic power.

This thesis does not try to examine every aspect of early British nuclear policy. Instead, it seeks to provide a strategic history of the first generation British atomic deterrent. In order to do so, it combines secondary source materials with documentation from both British and American archives. The information presently available in British archives alone is necessary but not sufficient to the study of this topic. The records on crucial issues such as Western assessments of the Soviet Union, its nuclear program, aerial defenses, and other potentially sensitive assessments of Western and Soviet capabilities, are more easily found in Washington than in London. Often, in fact, they are not publicly available in London at all. The American records also provide important insights into atomic negotiations with the U. K. The aim of this thesis is to fill a gap in the literature by placing the deterrent as a whole—both the bomb and its delivery system—in the general context of British strategy. Unlike other accounts, it seeks to assess the success of the program in *both* a military and a political sense. It does not isolate the atomic deterrent from its strategic roots and its political consequences, nor the bomb from the bomber.

Chapter one examines the political and strategic ends the deterrent was supposed to achieve. It considers what a deterrent strategy is and how early atomic deterrence is linked to older ideas of conventional deterrence and later ones of nuclear deterrence. The chapter shows how British ideas of atomic deterrence stemmed from a clearly defined idea of conventional deterrence, why the British decided to build an atomic deterrent and why they embraced a strategy of deterrence. Finally, it explores who the targets of the deterrent were and the strategic issues tied to their selection.

Chapter two examines the development of the atomic bomb. The first part of the chapter traces the state of the Anglo-American atomic alliance, an integral factor in the construction of the bomb. It then delves into how the program produced the bomb and evaluates its success.

The third chapter discusses the V-bombers, the second and equally important part of the deterrent, but the component which has not been integrated in discussions of the nuclear program. The chapter addresses the engineering and operational problems which the program had to overcome. It examines the advanced specifications defined for the new medium bomber force, and traces the troublesome development of all three aircraft. The chapter closes with an evaluation of the V-bomber program.

The final chapter assesses the first generation deterrent as a whole. It tries to answer the question: How well did the kiloton freefall bomb and V-bombers accomplish their political and military goals? It looks at how the deployment of that early deterrent force influenced the Anglo-American atomic and strategic relationship. It also examines how effective Bomber Command could have been as both an independent force and part of an allied one in case of war.

The British first generation nuclear deterrent was more than a sideshow in the Cold War, but less than the main event. Soviet-American confrontation held that honor. Nonetheless, until the 1960s, the United Kingdom was the second most powerful Western nation. It was a country that still thought of itself—and was seen by others—as a Great Power, a World Power. Although in the long run London did not keep its position as a preeminent political, economic, or military center, it did develop the tools to remain an surprising degree of influence even today. This thesis will examine why and how the atomic tool was shaped to serve this function and did so.

Notes

[1] Peter Hennesy, Cabinet (London: Basil Blackwell, 1986), 127.

[2] Ian Clark and Nicholas J. Wheeler, The British Origins of Nuclear Strategy (Oxford: Clarendon, 1989), 4.

Chapter I: British Deterrence in the Atomic Age

Britain's early atomic weapons program was inextricably linked to the idea of deterrence. Given historical precedent, the emergence of a hostile Soviet Union, and the unique vulnerability of the British Isles to atomic attack, the United Kingdom's leaders chose to base their defense on an atomic deterrent. Doubts about American targeting strategy forced them to do so through the creation of a deterrent independent of Britain's wartime ally.* This decision set in motion twin processes to gain the tools—the bomb and the bombers to carry it.

In theory, after 1945 Britain had strategic options other than atomic deterrence. The first was to maintain purely conventional fighting forces, able to wage war against any opponent at whatever level of intensity he might choose short of the use of atomic weapons. That might range from the feasible, counterinsurgency in Malaya for instance, to the impossible, the single-handed defense of Western Europe against a Soviet invasion. This kind of stance, however, was simply beyond British means. London's financial and material resources were crippled by 1945. It did maintain as large a conventional strength as any British Government could do and this taxed the weak British economy to its limits. In 1947, Britain had twice as many men under arms as the United States, and spent £1,667 million on defense throughout the world. Its troops were serving in Germany, Austria, Greece, Japan, other parts of the Far East, Southeast Asia, Palestine, the Near East, and Venezia Gulia.[1] London could not have spent more resources without permanently

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* Attempts at closer atomic cooperation will be examined in chapter two.

crippling an already struggling economy, yet clearly this level of strength could not match the greatest potential threat to British vital interests, Soviet conventional power in Europe.

Another possible course would have been accommodation with the Soviet Union. While Britain could cooperate with the United States and still retain its sovereignty, however, its interests were irreconcilable with a Soviet alliance. Collaboration with the Stalinist Soviet Union could lead only to subordination or even to East European-like subservience. In 1945-46, British statesmen of all persuasions were willing to pursue diplomatic cooperation on their own terms with the U. S. S. R., but when it became clear that this was impossible, all but an insignificant fraction on the left turned definitively against the idea. Defense through conventional means was impossible, slavery was loathsome; atomic deterrence was the only option left and atomic weapons were the key.

At its most basic level deterrence is a simple notion. It holds that one party will not attack another if it *believes* that attack will not bring gain, that no one would assault someone whom he *thinks* has an impenetrable defense or the ability to retaliate and cause unacceptable damage. A more formal definition would state that deterrence is an attempt to discourage an enemy from undertaking an action by threatening unwelcome injury if ever that action were taken. Deterrence can be further sub-divided into two categories, deterrence-by-punishment and deterrence-by-denial. In deterrence-by-punishment, a party threatens to retaliate and cause unacceptable damage which will outweigh any potential profit derived by the aggressor from an attack. The second type of deterrence,

deterrence-by-denial, attempts to convince an attacker that it will be unable to achieve whatever goals it sets out to reach.

At its core, deterrence is based on perception and the presumption of rationality. Unless one's adversary approaches strategy from a rational perspective, and unless one is able to understand what it values and what it fears, then deterrence will fail. Conversely, if an opponent believes that a party can prevent any gain worth the risk, then he will be deterred. Whether or not the party could actually have caused the damage which deterred the action is less important than the perception that he could and would have done so. A weak power perceived to be strong has more deterrent credibility than a strong power perceived to be weak. More formally, the issue of the credibility of a deterrent involves several criteria. First, the deterring power must actually have the capability to carry out its threat. An atomic deterrent without atomic weapons is only an empty threat. Second, the damage inflicted by the deterrent must be greater than any gain the aggressor could think would accrue by achieving its objectives. Third, the aggressor must believe that the deterring power would actually carry out the threat if the enemy undertook the proscribed action.[†] Although deterrence can be conducted with conventional forces, it is far more easily done with atomic ones (and even more so with nuclear weapons). Given the great destructive power of atomic weapons, little room remains to doubt the capability of the deterrent.

[†] For a more in-depth discussion of the theory surrounding deterrent credibility, see, for example, William W. Kaufmann, "The Requirements of Deterrence," in Military Policy and National Security, ed. William W. Kaufmann (Princeton: Princeton University Press, 1956), 12-38.

Of course, a strategy of deterrence and a deterrent itself are two different things. A power which bases its defense on deterrence will fail if it neither has nor is perceived to have the ability to retaliate. Thus, in 1946 any potential aggressor could be certain that Britain did not possess nuclear weapons, nor was likely to gain them in the course of a conventional conflict. By comparison, in 1946 an American deterrent was more (but not wholly) credible.[‡] Hiroshima and Nagasaki bore witness to the U. S.'s capacity *and will* to use nuclear weapons on an opponent. The difference between these two powers was simple: the U. S. had a deterrent—a thing—to pair with deterrence—an idea: Britain did not.

The nature of that deterrence and deterrent in the late 1940s and early 1950s was far from that which evolved during the 1960s and 1970s. In the earlier period, delivery vehicles were highly vulnerable to destruction on the ground and in the air—closer in fact, to the situation with conventional bombers over Germany in 1943 than to that of submarine launched ballistic missiles, intercontinental ballistic missiles, and cruise missiles of 1980. Again, an atomic bomb of 1945 or 1950 vintage could inflict damage equal to a 1000 bomber raid of 1944. A hydrogen bomb of 1965 could deliver all the firepower of World War II on a single point in a single moment. United States Secretary of Defense Robert McNamara summarized the nature of deterrence in the nuclear age during 1962 when he said, "'nuclear weapons serve no military purpose whatsoever. They are totally

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[‡] For a detailed discussion of the American deterrent's credibility in the late 1940s, see Harry Borowski's Hollow Threat.

useless—except only to deter one's opponent from using them."[2] In the atomic age this statement would have been untrue, and the world a more dangerous place for the fact.

Unlike the hydrogen bomb, the atomic bomb at least *could* be conceived of in a conventional framework, and its use might seem a rational act of state. Moreover, in the early Cold War era, atomic bombs were relatively few in number and destructive capacity, and one nation, the U. S., was far stronger in this regard than any other. Only one country had the ability to wage atomic war; insofar as it could be waged at all. While the Soviet Union could dominate an enemy in the conventional arena, the United States could balance that off with the atomic threat. Conceivably, an atomically armed Britain could either do the same, or help the U. S. in the task. Twenty years later deterrence had become mutual, parallel, and far more massive. Strategy in the atomic age should not be seen through the prism of the nuclear era. Mutually assured destruction and graduated deterrence were concepts for a future where both sides possessed many times the weapons necessary to destroy the other. Until the middle 1950s, atomic weapons were seen as serving both a deterrent strategy and as a viable warfighting tool.

Deterrence can take many forms and some of them were a fixture of political and military thinking long before Hiroshima. It is a particularly appealing concept for a satisfied power, that is one who wishes to maintain the general status quo. Since the 1760s Britain had played this role with other Western powers, and deterrence appeared in British defense planning long before the nuclear age. It was part of Britain's standard strategic repertoire in the Victorian age. Thus, one classic British move in the Eastern

Question was to despatch the Mediterranean Fleet to Besika Bay, a station just outside the Dardanelles and a short sail from Istanbul. This move was intended, among other things, to provide a credible deterrent which would back Britain's opposition to Russian military intervention in the Ottoman Empire.[3] In these cases deterrence did not exist in a pure form, but rather in an alloy with other types of strategy. It usually was pursued in an *ad hoc* manner, to handle a specific crisis, rather than in a continual and systematic fashion, year in and out.

An entirely modern concept of deterrence was at the heart of much of British naval and air planning before World War II. Thus, throughout the interwar years, the Chiefs of Staff discussed Singapore's role in Imperial defense with the language and logic of deterrence. They argued that a main fleet base at Singapore backed by a fleet in the Mediterranean would deter a Japanese attack on the British Empire, and that certain sorts of defenses would deter a Japanese *coup de main* against the base. As early as 1928, they debated whether the presence of 15-inch guns was an adequate deterrent to Japanese attack on the base. The First Sea Lord Sir Charles Madden argued, "the Navy certainly did not like such operations [against ports], and if 15-inch guns were at Singapore he, personally, would feel quite satisfied as to their deterrent effect."[4] In 1934, another First Sea Lord, Ernle Chatfield expressed,

> his personal view that efficient gun defences represented a very definite deterrent to naval attack. Once the gun defences at Singapore were installed he would no more think of making a naval attack on Singapore than we thought of attacking Heligoland during the war. It would not be worth the risk.[5]

Discussion of deterrence at Singapore was not limited to naval forces alone. Hugh Trenchard, the Chief of the Air Staff, argued that basing aircraft at the installation would have a deterrent effect equal to fixed defenses. In 1929, he stated, "that for the two squadrons of bombers to act as a deterrent to attack in the same way as 15" guns it is essential that they should be stationed at Singapore in peace . . ."[6]

Again, when encouraging Australia to buy a battleship in 1935, Chatfield argued,

> It can be said, therefore, with assurance that the presence of a capital ship in Australian waters would exercise a very great deterrent effect both against raids on Australian territory and against attack on Australian trade and make such action by Japan very much less likely than if cruisers are the largest ships maintained by Australia.[7]

These examples highlight the most common form of British deterrence before the Second World War. It aimed to prevent a single action by a single enemy. Britain intended Singapore's guns (or aircraft) to prevent a Japanese naval attack on the port, but it did not expect these measures to prevent a Japanese bombing raid, blockade, or a land invasion against the British Empire or to affect the actions of Italy, the Soviet Union, Germany, or the United States. It was a precise force aimed against a particular threat by a specific enemy. Allied to this often was a political calculation—that if a state was prevented from taking a given action, it would be more likely to take another, one more favorably suited to British interests. This form of deterrence rested on conventional force and was more specific and linked to diplomacy than was true of the form of deterrence that emerged by the 1960s.

Debates over the R. A. F.'s mission during the interwar years straddled the line between this precise form of deterrence and the generalized concept of the postwar era. These debates also foreshadowed the post-war role of the R. A. F. The concept of deterrence was central to the British idea of strategic airpower and to its entire strategic policy, but still all this rested on conventional forces and the limits to the deterrent effect of such forces were obvious. Thus in 1934, the Chiefs of Staff considered,

> whether, in fact, [bombing munition centers] was going to be a deterrent to Germany. Would Hitler say he was so afraid of bomb attack on the Ruhr that he would not attack the Polish corridor? In fact the problem resolved itself into this —Was anything less than a really vital measure going to be a sufficient deterrent if a nation was really determined to go to war? Would the fact that it might have its munition factories and centres damaged by air attack be vital enough to deter such a country from going to war? Would in fact, that air threat have the same effect as the threat, say of German armies mobilised on the Austrian or Polish frontiers, with the obvious chance of those countries being entirely overrun?[8]

With the atomic bomb, air forces suddenly had the 'sufficient deterrent' for which the Chiefs of Staff had searched in vain before the Second World War.

Thus, in 1945 Britons were intellectually predisposed to view atomic weapons from the standpoint of deterrence, just as much as that of *Realpolitik* or the defense of the status quo, from a perspective which unified political and warfighting matters. To Sir Henry Tizard, Britain's leading authority on the military applications of science and charged by the Chiefs of Staff with assessing the probable effects of modern technology on war, the atomic bomb provided a guaranteed 'vital measure.' His *ad hoc* committee reported in 1945,

> assuming the worst; the only answer that we can see to the atomic bomb is to be prepared to use it ourselves in retaliation. A knowledge that we were prepared, in the last resort, to do this might well deter an aggressive nation. Duelling was a

> recognised method of settling quarrels between men of high social standing so long as the duellists stood twenty paces apart and fired at each other with pistols of a primitive type. If the rule had been that they should stand a yard apart with pistols at each other's hearts, we doubt whether it would have remained a recognised method of settling affairs of honour.[9]

Inherent in this passage is a recognition both of the colossal power of atomic weapons and the change they would wreak on strategy. Tizard's comments are remarkable not only for their clarity, but also for the early date at which he recognized the scale of the nuclear danger and the nature of Britain's only solution to it. Nor were these views limited to Whitehall—almost immediately after the bombing of Hiroshima the left wing journalist George Orwell published an intelligent forecast of the deterrent effect of atomic bombs[10], which also was central to the world he imagined in Nineteen Eighty-Four. Such views became orthodox in Whitehall, which moved more quickly over the next decade toward concepts of massive retaliation and assured destruction than did Washington.

British thinking about nuclear deterrence grew from familiarity with a related but not identical topic, conventional deterrence, and it was heavily shaped by the most powerful experience about strategy in peacetime of these statesmen, appeasement before World War II. This approach was surprisingly advanced, though it was also far from perfect. As the extensive theoretical work on nuclear deterrence suggests, not to mention British plans for atomic warfare, the advent of atomic weapons had not in fact guaranteed credible deterrence or assured destruction. However, strategic theory was only beginning to come to terms with the unique nature of nuclear weaponry when Britain decided to acquire the atomic bomb. As Tizard's counsel suggests, it still offered the possibility of assured deterrence.

To the mixture of the pursuit of stability in the Western World, a strategy of deterrence, and a recognition of the power of the atomic bomb, was added another element—a major enemy. The Soviet Union appeared in British military thinking before the war even ended. In 1944, the Committee on Post-Hostilities Planning defined areas of British "vital" strategic interests where conflicts might arise with the Soviets.[11] In 1945 one Chiefs of Staff Committee paper on the U. K.'s atomic energy program noted the danger that it might, "stimulate the U. S. S. R. to an aggressive military reaction,"[12] and the Soviet Union became the center of British war plans.[13] By 1948, the Joint Planning Staff identified the U. S. S. R. as the only country with both the capacity and intent to threaten the U. K. and the Commonwealth.[14]

Simultaneously, though more slowly, British political leaders reached the same conclusion. Although Britain tried to resolve post-war tensions with the Soviet Union, it became harder to do so. From Potsdam onward, the Soviets applied pressure to traditionally British concerns. The U. S. S. R. urged Turkey to allow Soviet military bases on the Straits and demanded territory in two border provinces. This move indirectly threatened Britain's all important Mediterranean link to India and the Far East.[15] Attlee kept troops in Greece after the war because, "if we hadn't, the Communists would have taken over everything and there wouldn't have been any hope of a peaceful Government."[16] A Soviet delay in removing troops from the northern half of Persia, in accordance with previous agreements, posed a potential threat to British oil supplies.[17] Meanwhile, the states of Western Europe were weak and the U. S. S. R. patently had the potential to subvert or to smash them. Whether or not Britain wanted to preserve good wartime relations, Stalin increasingly left Britain with no choice but to regard the Soviet Union as a threat to her national security. "To an extent that is often forgotten in the light of later events Britain . . . became during this period the primary . . . target of Soviet diplomatic and propaganda attacks . . . ."[18] And until 1947 Britain could not be sure how the U. S. would assist it in the worst case—or whether it would do so at all.

The Soviet Union became the target for British deterrence, but it was a target unlike any in prewar years. When London used deterrence before 1945, its goal was to dissuade individual leaders from undertaking specific actions. The U. S. S. R.'s size and vast conventional military resources prevented an application of the same strategy. The British armed forces in the late 1940s remained large and proficient, but Soviet military potential was vastly superior to any conventional land or air force the U. K. could field. Moreover, Britain's historic strength, seapower, was ineffective against the Soviet Union. A blockade of Leningrad or Vladivostok would not damage the Russian economy in the same way that a blockade of Tokyo or Hamburg might have hampered that of Japan or Germany. Thus, a threat to blockade would not influence a Soviet leader to nearly the same extent as was true of most of Britain's opponents. To deter potential Soviet threats, Britain required a weapon large enough to figure in Moscow's calculations.

A British atomic deterrent aimed at the Soviet Union was different from its prewar conventional deterrents in two further ways. The threat and the intended effect were far more generalized. The deterrent was not directed against individual acts *per se*, but instead at aggressive Soviet behavior more generally—in fact, at all the fundamental components of its policy simultaneously. Moreover, an atomic weapon could not be precisely directed against specific enemy military capabilities. Whereas in a process of point defense 15 inch guns might counter the threat of a Japanese invasion fleet directed at Singapore, atomic weapons had to be used in a strategically offensive fashion in order to be used at all in war, and even if aimed at individual installations, they would destroy far larger areas and provoke an unlimited response. They were not a rapier used to disarm an opponent, but a club to beat him into submission.

Britain opted for a deterrent strategy centered on an atomic capability for military and political reasons. The chief military reason was the U. K.'s unique and utter vulnerability to atomic attack. The destructive power of atomic bombs made any conceivable air defence system impotent. In 1940, if a given German bombing raid suffered 10% casualties then Fighter Command could rightfully claim a victory. No air force could continue raids at that rate of attrition. After 1945, however, even if Britain's air defenses inflicted 90% casualties on a raid by 200 atomic-armed Soviet bombers—an almost impossible task—then the twenty largest cities in Britain could be destroyed and with them half of its population and industrial capacity. During the battleship era, Britain's blessing had been the fact that it was a small isolated island. During the atomic age this became a curse. Heavy population and industrial concentrations, not to mention the administrative center of London, were all within range of Soviet air power. Compared with the United States or the Soviet Union, Britain was far more vulnerable to atomic weapons. This problem declined with further technological advances. After the advent of the hydrogen bomb, both superpowers became as exposed to devastation as the U. K., but before that their physical size and distance provided protection which Britain did not have. As Air Vice Marshal Stewart Menual later wrote, "Few people in the early 'fifties had seen the effects of nuclear weapons or appreciated the hard truth that interception and destruction of all bombers sent against this country in a nuclear attack would have been virtually impossible."[19]

As early as January 1946, the Joint Technical Warfare Committee told the Chiefs of Staff that effective air defense was impossible: "one must count the bombs that get through rather than the aircraft shot down."[20] The American warplan "Dropshot," written in 1948, attempted to quantify Britain's defense problem. It said that British planners estimated they could force the Soviets to abandon a sustained strategic air offensive by having one fighter for every two enemy bombers. In 1957,

> The initial aircraft requirement for defense against bombers would therefore become about 700 fighters. As soon as the Soviets provide fighter escort, an increased requirement would develop. That might be as much as 200 additional fighters. The total requirement for air defense of the United Kingdom would then increase to about 900 fighters, all of which should be high-perfomance all-weather interceptors.[21]

The R. A. F. did not consider even this number of fighters adequate—in fact, it did not think that any possible air defense system could handle the problem. Commenting on Exercise Ardent in 1952, a test of the U. K.'s air defenses, the Chief of the Air Staff told the Secretary of State for Air, "The problem of an adequate interception and kill rate is largely one of numbers. We shall never have enough modern fighters to get a sufficiently high rate, when atom bombs are included in the attack, unless we can do something to reduce the attack at its source—i.e. the bases in Russia."[22] Political leaders also recognised Britain's vulnerability. Brian Cathcart paraphrases a memorandum written by Prime Minister Attlee in 1945,

> . . . the emergence of the new weapon had made nonsense of all previous thinking about the future of Britain. Far-flung strategic bases were now irrelevant since the heart of the Empire was acutely vulnerable to devastating attack; in a country as small as Britain, moreover, a dispersal of industry, airfields and arms factories would be useless; bomb-proof basements and ARP services were now 'just futile waste' . . . 'It is difficult for people to adjust their minds to an entirely new situation. Even the modern conception of war to which in my lifetime we have become accustomed is now completely out of date.'[23]

Given its compact geography Britain could not block a Soviet atomic air attack through defensive means, nor could it hope to avoid damage of an unprecedented sort in even a victorious war. Britain's leaders saw only one way to defend themselves against a potentially hostile enemy armed with irresistible weapons, through a variation on the historically practiced doctrine of deterrence. Consonant with tradition, they had a specific target in mind, the Soviet Union, but their own counterthreat was unlike any Britain had ever mounted before. Initially, Britain pursued the ability to target and destroy whole industries and cities. Although it subsequently moved its focus to more specific military installations, even this refined planning was still far less restrained and focused than common in its usual historical practice. Not only the Soviet aircraft threatening Britain would be destroyed, but also their bases, and even perhaps the cities around them. In this way, the atomic force would play both a deterrent and warfighting role. In the first capacity, the threat of its employment, and all that would mean for Soviet power and their own lives, would give Communist leaders pause. If the threat failed, atomic weapons could eliminate the principal threat to British survival—or at least ensure that Britain took its enemy with it.

Military necessity provided only one justification for Britain's atomic program. The most important political reason why the U. K. adopted an atomic deterrent was to remain a Great Power. This reason was so basic in the thinking of British decision makers that they rarely felt the need even to articulate it, but modern historians are fully aware of its significance. In her official history of British nuclear policy, Margaret Gowing writes, "British production policy 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."[24] In the immediate post-war years, Britain did not consider itself in significant or irrevocable decline. The size of its military and the extent of its commitments were those of a Great Power. Thus, in 1950, the United States National Security Council counted seven areas of the world where the Royal Air Force had ongoing commitments: the United Kingdom itself, Germany, Cyprus, Malta, Malaya, Aden, and Hong Kong. In addition, twenty-two other specified treaty commitments might require military force.[25] It was only natural that such a power would want military forces commensurate with its commitments. David French writes, "Attlee and his colleagues [were not ready] in 1945 to abandon their pretensions that Britain was still a great power."[26]

Great Power pretensions, however, were not the only political force behind Britain's drive for atomic power. Britain had to manage both the Soviet threat and the American ally. Political reality forced Britain to pursue a deterrent force to influence not only the Soviet Union but also the United States. It had to guarantee that American, and later joint, warplans considered the U. K.'s strategic needs. Nor could it absolutely depend on indefinite U. S. cooperation or even a purely American deterrent. These concerns about its closest ally compelled the U. K. to develop an independent deterrent.

British postwar grand strategy, at least until the retreat from east of Suez after 1970, centered on the means to retain and exercise a role as a leading world power. To keep that position, Britain needed stability in Western Europe. In the late 1940s, London expended considerable time and diplomatic effort trying to achieve that goal. In 1944, the Post-Hostilities Planning Committee called for a single West European defense organization. Although nominally intended for purposes of defense against a resurgent Germany, the paper also recognized that such a group could also deter a Soviet invasion.[27] The Committee also realized that the Europeans would be unable to fend off the Soviets alone; American aid would be essential.[28] The first recognizable step towards a Western European defense organization was the 1947 Dunkirk treaty with France.[29] Foreign Minister Ernest Bevin approached the Cabinet the next January about creating several such agreements with other Western European powers to help defend them against the Soviets.[30] For Bevin, "the prime aim of European co-operation [was] to strengthen Britain's role in the world."[31] On 17 March, Britain, France, and the Benelux countries signed the Brussels Treaty pledging assistance in case of armed attack.[32] Besides giving confidence to the Europeans, the treaties were also intended to bring the Americans into the defense of the Continent, with some success. After the Brussels treaty, President Truman declared, "'I am sure that the determination of the free nations of Europe to protect themselves will be matched by an equal determination on our part to help them protect themselves.'"[33] Eventually, in April 1949, the North Atlantic treaty brought that American cooperation.[34] According to Saki Dockrill, "the prime virtue of NATO to Britain . . . [was] as a political and psychological means of uniting the Western democracies in the face of Soviet threats . . ."[35]

According to Elisabeth Barker, the West European alliances accomplished three overlapping goals. They buttressed European resistance to Soviet pressure, they served as a deterrent to Soviet aggression, and most important, they signaled to the Americans that Europe was willing to defend itself and worthy of help.[36] Thus, the goals of Britain's atomic weapons program and of its more general diplomacy were very similar. Both attempted to deter Soviet aggression, both tried to tie the U. S. to British and Western security more generally, and in both cases military and diplomatic calculations were intertwined. Military alliances were accepted specifically in order to produce political results, military forces constructed as part of a move in diplomacy, plans for war formulated in order to reduce the likelihood that war would break out. Atomic weapons were only one part of a larger grand strategy aimed at enemy and ally alike, in which any one tool had uses both for diplomacy and war.

When it came to pursuit of an alliance with Washington for British and European defense, London was following a reliable model—its generations old attempt to maintain friendly ties with the strongest nations and to bind them into support for the general status quo. After the Second World War, only the United States could fulfil the role held earlier by the Netherlands, Prussia, or more recently France. The single most effective tool with which Britain could gain America's confidence in the postwar environment was an atomic deterrent. In this way, London's policy of gaining American attention through atomic weapons was consistent with historical practice.

These military and political concerns were linked together in the issue of targeting priorities for atomic weapons. Here Britain and America followed divergent paths throughout the early cold war, and this fact in itself impelled the British toward an independent nuclear deterrent. The initial post-war British plans for a strategic air offensive emphasized counter-value targets such as oil, whose incapacitation would cripple or destroy Soviet war-making ability over the long-term. Thus, a Joint Technical Warfare Committee paper in 1946 stated that the atomic bomb was best used against "large urban targets," not points such as airfields and submarine pens.[37] This counter-value bias marked the Chiefs of Staff and their early war plans. Plan "Sandown," of 1948 stated,

> If the Strategic Bomber Force were employed on the bombing of oil refining centres in the Caucasus at Baku, Grazni and Batum, it would very seriously embarrass the enemy and would, in time, considerably reduce the threat to our Egyptian base. Baku is of such importance to the Russians that it is considered that this target should be attacked by weapons of mass destruction.[38]

British plans for war with the Soviet Union of the late 1940s sought to place atomic bombs in the context of a hybrid version of the Second World War—not surprisingly, because these plans were written before the Soviets had a viable atomic warfare capability and before the invention of fusion weapons and tactical nuclear weapons. Warplan "Galloper", written in 1949 and finalized the following year, set out the Allied aim in a war starting in 1950 or 1951 as, "To ensure the abandonment by the Soviet Union of further military and ideological aggression and to create conditions conducive to world peace."[39] It envisioned a simultaneous Soviet invasion of Western Europe and the Middle East (including Greece and Turkey), aerial bombardment of the U. K., a limited campaign in the Far East, limited attacks against Canada and the U. S., a full scale offensive against Allied sea communications, and worldwide sabotage and subversive actions. Since the thirty atomic bombs the U. S. S. R. was assumed to possess under these circumstances could not break either Britain, Canada, or the U. S., "for political or psychological purposes," the Soviet Union might divide its stock between all three, aiming not to destroy but to disrupt their ability to function and fight.[40] Following completion of these objectives, Soviet forces would launch a full scale air and sea offensive against the U. K. along with campaigns in Scandinavia and the Iberian peninsula.[41] To counter this immense Communist invasion, the Allied strategy was,

> (a) to launch a strategic air offensive using atomic bombs against Russia from the outbreak of war; (b) to hold securely the air bases and sea areas essential for launching this air offensive; (c) to defend certain other areas essential to our strategy; (d) to defend the Allied main support areas; (e) to control the sea and air communications essential for the security of the above bases and areas.[42]

The aim of the strategic air offensive would be to destroy "vital Soviet war-making capacity and to retard Soviet advances in Europe."[43] Operations in Western Europe would be aimed at making a stand at the Rhine. Failing that the Allies would try to maintain a "substantial bridgehead" in Western Europe, possibly holding in the Pyrenees. Meanwhile, Britain would try to stall the Soviets in the Middle East and the United States would build up a major support base in Northwest Africa to support forces in the Western Mediterranean and for a prospective re-entry into Europe.[44] Three months into the conflict, the plans required reevaluation of the strategic air offensive. If the atomic air attacks had broken the Soviet war machine, the Allies would negotiate surrender terms and establish a friendly government in its place. However, if the air offensive had failed to achieve success, "Galloper" predicted that both the U. K. itself and British bases in the Cairo-Suez area would be seriously threatened. At this point, the plan recommended reinforcing the U. K. at the expense of the Northwest African and Middle Eastern bases.[45]

"Galloper" illuminates British thinking of the late 1940s and early 1950s about the place of atomic weapons in actual warfighting, as opposed to deterrence. They hoped that a protracted strategic air campaign (lasting months rather than hours or days) striking at Soviet forces and industry would cause the collapse of its armed aggression and perhaps of the Soviet government itself. As Slessor wrote,

> . . . it is my belief that the operations of the U. S. atomic bombers upon centers of administration, communication and industry within Russia would have a profound effect, material and psychological, upon the conduct of the invasion. Even Russians are human, and I do not see Russian land and tactical air forces forging their way unruffled way across Europe with an atomic deluge descending upon the vital centers of their home land [sic].[46]

Just as importantly, British officials did not believe that atomic strikes would instantly destroy either Soviet military ability or will. This British view of atomic warfare was closer to the strategic bombing campaigns of World War II than the modern conception of total nuclear devastation. Conventional forces still played a large role in this form of "total war," and Soviet conventional forces without atomic weapons were regarded as having the ability to win a war by themselves against Britain. During a conference held to coordinate Allied emergency war plans, the U. S. Joint Chiefs of Staff stated, "We do not expect air action alone to be decisive."[47] The British representative showed the Churchillian roots of his thinking when he said, ". . . it must be remembered that the Mediterranean is a vital location for striking the Russians from underneath."[48]

In the early postwar era, British planners often did see atomic bombs simply as an unusually large bomb and did try to fit them into a pre-atomic strategy. Soon, however, their views of strategy were transformed as awareness of the power of the weapon and the vulnerability of the U. K. grew. In particular, the R. A. F. turned increasingly toward an atomic counter-force strategy— destruction of Soviet atomic weapons and their delivery systems before they were used. Although belief in the value of counter-value strategy never vanished, it did decline in strength. All this was linked to the gradual recognition that atomic bombs had transformed the nature of offense and defense: that since just one full scale Soviet atomic attack could destroy the U. K., the overriding task in war of Britain's atomic forces must be to prevent the Soviets from ever mounting such an attack. As Slessor put it, "the counteroffensive is an indispensable element in air defence."[49] Only when this requirement was met could Britain devote substantial forces against conventional counter-force targets or counter-value targets. In 1947, future Chief of the Air Staff Sir William Dickson wrote, "An air striking force backed with an appropriate stock of atomic bombs, [is] to be our main deterrent against atomic war and our *principal offensive defence weapon* if war comes [emphasis added]."[50] That same year, the joint planning staff wrote,

> [current intentions] suggest that overriding priority should be given to defence at the expense of offence, and it was the view of the Chiefs of Staff that the offensive air force must have top priority, since it is, in effect, an essential element in the defence of the United Kingdom.[51]

In 1951, the Air Ministry quantified this assumption when it reported that an atomic offensive against Soviet bases could reduce the scale of attack on Britain by 50%.[52] By 1952 it and the Chiefs of Staff committee both "recommended that offensive action must be taken against the source of this threat immediately on the outbreak of war to reduce the scale of attack," and thought that this might be done through a force of 260 bombers with 50 atom bombs.[53] This notion became enshrined in the warplan "Fairfax", which assumed the use of atomic weapons by both sides. It stated, "The defence of the United Kingdom will rest upon . . . [the] ability to launch an air counter-offensive against the bases from which the Russian air, submarine and minelaying offensive would be mounted."[54] In 1936, the Deputy Chiefs of Staff had argued whether, "the best place to attack the wasps was either 'in their nest' or 'over the jam,' i.e. London."[55] Fifteen years later, they realized that if ever the wasps reached the jam, the war was lost.

Britain's targeting strategy changed markedly during the late 1940s. As Clark and Wheeler state, "The British planners' emphasis upon a doctrine of pure retaliatory deterrence was to be short-lived. As early as 1946, a theme began to emerge in the planning documents which gave a greater role to active damage limitation or, in other words, to attacks upon the Soviet Union's war-making, and particularly atomic war-making capability."[56] Britain's plans began with an emphasis on counter-value targets, but realization of the U. K.'s unique vulnerability converted them toward atomic counter-force. Britain's realization of its vulnerability and alteration of plans to compensate came earlier than America's. As a result, American policy continued farther along the path Britain had abandoned. American plans also began with a preference for counter-value strikes that, in the words of one 1945 study, aimed to, "destroy the Soviet Union's capacity to make and sustain land warfare by wrecking her industrial and research and development centers."[57] These war plans directed U. S. air power against retardation or "Romeo" targets which would slow the westward march of the Red Army through Europe.[58] Thus, Plan "Harrow", a warplan for 1947, called for the destruction of twenty Soviet cities using fifty bombs. It anticipated that this would paralyze half the U. S. S. R.'s industry. Two years later, warplan "Trojan" stated that the purpose of the American air offensive,

> is to hit hard and to attack a large number of Soviet urban areas in the shortest possible time. It is hoped thus to exploit the effects of surprise and shock, to provoke the spread and compounding of disaster rumors, and by widespread

damage to interdependent industries to complicate and retard processes of recuperation.[59]

The larger the American atomic stockpile became, the more extensive the plans for attacking Soviet industrial and urban targets. Only after the first Soviet atomic explosion in 1949 did U. S. planning begin its turn toward counter-force targeting, and that turn took years to be executed. In American targeting language, "blunting" or "Bravo" targets were supposed to take priority from plan "Dropshot" onward. However, Strategic Air Command (SAC) rejected the first list of Bravo targets because it felt that they simply could not be achieved. The plan required visual prestrike reconnaissance on too many isolated targets, which would be difficult to locate, and whose isolation would waste the atomic bomb's potential to produce "bonus" damage against nearby installations.[60] SAC did eventually draw up target lists around the new priorities, but very slowly.[61] Presumably, as estimates of and intelligence about Soviet nuclear capabilities grew, SAC moved to counter them through counter-force—Bravo—targeting. By 1958, when the two Air Forces finally compared their targeting strategies, Chief of the Air Staff Boyle said that every target on Bomber Command's list was also on SAC's.[62]

British military and political leaders always had a clear idea of the targeting strategy best suited to achieve their objectives. They also felt that they could not depend on the U. S. to share the same priorities—nor did they ever know what that American strategy would be. One of the foremost proponents of a separate British bomber force with its own targeting system and opponents of the "Leave it to America" theory was

Chief of the Air Staff Sir John Slessor. In May 1949, he wrote an article in the Sunday Times that called for a force tailored to U. K. needs, such as anti-submarine warfare.

> [A] pressing requirement may be for action against enemy submarines in harbour and in production . . . Are we going to leave all that to the Americans, who with the best will in the world . . . cannot be expected to take the same view of the anti-submarine war as we are bound to do, and would have a host of other commitments and priorities for the Bomber Force?[63]

In 1950, he outlined targets for a bomber force including the enemy airfields from which bombers might threaten the U. K. were based.[64] He wrote,

> We can not be dependent for all these things upon the Americans, who have different ideas for the employment of their strategic bomber squadrons. We can not to that extent surrender our capacity for strategic initiative, even to so loyal and powerful an Ally as the United States.[65]

This issue was rendered even more complex by ignorance of U. S. targeting plans. The Anglo-American military alliance faltered in the first few years after the war but it revived quickly thereafter—except in the critical area of atomic targeting. When Churchill visited Washington, D.C. in 1952, he received a detailed briefing on Strategic Air Command's capabilities. His surprise at that organization's strength shows just how little information the British possessed.[66] The emergency outline for war in 1953, Plan "Fairfax" admitted, "we have no knowledge of [the American strategic air offensive] detailed plan."[67] As late as 1954, Harold Macmillan wrote, "no arrangements had yet been made to specify which enemy targets, especially those most important to the United Kingdom, would be dealt with immediately by American bombers."[68] This American hesitancy to inform the U. K. of its targeting plans, combined with doubts as to

Washington's priorities, reinforced the British need for an independent deterrent able to either carry out its own strikes or to become part of a known joint targeting plan.

Doubts about American intentions went beyond differing target priorities. Some Britons feared a resurgence of American isolationism, especially in the period right after the war. Prime Minister Attlee later said,

> We had to bear in mind that there was always the possibility of their withdrawing and becoming isolationist once again. The manufacture of a British atom bomb was therefore at that stage essential to our defence. . . . Although we were doing our best to make the Americans understand the realities of the European situation —the world situation—we couldn't be sure we'd succeed. In the end we did. But we couldn't take risks with the British security in the meantime.[69]

Britain feared not just American isolation, but U. S. action. In the Quebec Agreement of 1943, Churchill secured a veto over any American use of the bomb. Each country agreed to "not use it against third parties without each other's consent."[70] Although Attlee later surrendered this power, he tried to keep a say in America's atomic operations. He particularly feared that an aggressive U. S. use of atomic weapons from bases in the U. K. would lead to Soviet air strikes on Britain.[71]

An incident during the Korean War fueled Attlee's fears. President Truman's imprudent press conference hinting that atomic weapons might be used in that conflict triggered a visit to Washington in December 1950. The Prime Minister feared both Truman's comments and his lack of control over the American Supreme Commander in Korea, Douglas MacArthur. At a secret meeting, Truman reassured Attlee that atomic weapons would not be used.[72] Nonetheless, this incident reinforced the British desire to influence American policy. These views were widely shared. In 1955, Minister of

Defence Macmillan summarized the reasons why Britain could not simply leave the West's deterrent to the U. S.,

> Politically it surrenders our power to influence American policy and then, strategically and tactically it equally deprives us of any influence over the selection of targets and the use of our vital striking forces. The one, therefore weakens our prestige and our influence in the world, and the other might imperil our safety.[73]

Once Britain had opted in favor of building an atomic deterrent it required a method of delivery. It adopted the R. A. F.'s Bomber Command as that means. This decision rested on historical and pragmatic grounds. Traditionally, strategic bombing had been one of the R. A. F.'s roles since its creation. Practically, when these decisions were reached in the late 1940s, there was no method to deliver a bomb accurately, except by manned bomber.

The occasion and one of the causes for the creation of the R. A. F. in 1917-18 was strategic air warfare. The R. A. F. created its first strategic bombing force—the Home Defence Air Force (HDAF)—in 1922. Significantly, the HDAF was originally designed for purposes of deterrence and diplomacy in response to the (admittedly exaggerated) threat from the French Air Force. "Whitehall feared that France might use the FAF to blackmail Britain and refused to live on French sufferance, because 'our diplomacy might be weakened if we are at the mercy of some other Power'."[74] Later, the HDAF was turned to deal with the more real menace of Germany. The importance of the R. A. F.'s strategic bombing role varied until World War II, but it always remained a leading element of Britain's defense.

While it was not a universally shared opinion, some in the R. A. F. believed that strategic bombing had won World War II.[75] The combination of U. S. daylight raids and British nighttime raids had ground German air defenses down and starved the Nazi war machine of vital production. Following its prewar doctrine, the R. A. F. believed that Britain's aerial security could only be safeguarded by bombing—by attack rather than defense. The Royal Air Force War Manual put it thus,

> The first aim of the Air Force, however, must be to win general air superiority, and this is a condition which can only be achieved by the offensive. The air war must be fought out <u>over the enemy's own territory</u>. He must be forced on to the defensive and kept there by relentless continuous attacks on his vitals, until as in 1944, he is building virtually nothing but defensive fighters, and ultimately as in 1945, we are destroying them almost as fast as they are produced. . . . <u>And it is the only way in which real air superiority can be secured over our own country</u> . . . . [emphases in original][76]

Lord Tedder, Chief of the Air Staff during the war, later wrote,

> I am utterly convinced that the outstanding and vital lesson of this last war is that air power is the predominant factor in this modern world and that although methods of exercising it will change, it will remain the dominant factor so long as power determines the fate of nations.[77]

Not only did Bomber Command want the strategic bombing role, in the post-war years it was also Britain's only realistic choice for a delivery vehicle. In 1945, the world's only deliverable nuclear weapons were free-fall bombs, while both cruise missiles like the V-1 and ballistic missiles like the V-2 were inaccurate and unreliable; the V-2 had a 1500 mile range but missed its intended target by an average of seventy-five miles.[78] Even Wernher von Braun believed that the V-2 had very little future as a military weapon. Rather, its future role would be in atmospheric research.[79] In any case, Britain lagged behind the other powers in developing this technology or in capturing German scientists who could.

Britain's problems developing aerial defenses also influenced the decision to rely on manned bombers. As the V-bomber program took shape in the late 1940s, complex surface-to-air missile systems seemed to be a long way off. The head of the guided weapons department at Farnbourough from 1948 to 1953 later recalled,

> There was a heck of a problem getting those missiles to fly and those V-bombers would have had a free run for a long time. It was a long haul to set up a complex guided missile system, though most advanced countries have done it now, and we could build V-bombers and get them operational years before there was a hope in hell of anyone saying they knew for sure that they could cope with them.[80]

In the early cold war era the bomber was Britain's proven weapon of choice for the deterrent. Whose bomber was another matter. In 1948, the Navy attempted to establish a foothold in the strategic atomic role. It called for the construction of two or three aircraft carriers capable of launching bombers built to the same specification as the V-bombers. Each carrier would hold from eight to twelve bombers suited to carry an atomic bomb 1500 nautical miles at 500 knots. The aircraft carrier's mobility would allow it to reach targets otherwise untouchable by land-based bombers.[81] The Air Staff replied that sea-launched aircraft could not carry a 10,000 pound bomb load and that the Navy had minimized the number of overseas bases from which a land-based force could operate. The First Sea Lord suspended the proposal in October 1949.[82] Not for another decade and then through the medium of a different sort of warship would the Royal Navy again threaten the R. A. F. in this role. In making this proposal, however, the Navy moved toward views expressed by Sir John Slessor, "A Bomber Force to-day fills the place which the Battle Fleet held so nobly for so many generations."[83]

After the Second World War, Britain had compelling military and political reasons to build a deterrent and to adopt a policy of deterrence. It formulated these decisions over an extended period, during which British strategic thinking and war plans took different forms, but early British views toward nuclear issues had been distilled into a clear and mature form in the Global Strategy Paper of 1952. The roots of deterrence policy related in this paper, "can be traced back as far as 1945."[84]

The paper began by identifying the primary threat to world security and British interests. "The Free World is menaced everywhere by the implacable and unlimited aims of Soviet Russia. Using Communism as a convenient and dynamic instrument, Imperialist Russia seeks world-domination exercised from the Kremlin."[85] Against this threat, and in the context of the "Free World", Britain is allocated four roles,

> In essence the military problem facing the United Kingdom is four-fold; first, British interests in the Cold War have to be safeguarded, due influence on American policy being exercised throughout; second . . . we consider that the United Kingdom should play its part—albeit a small part—in the main deterrent (the Allied atomic offensive); third, the United Kingdom must prepare for war in case the deterrent fails; fourth, due regard must given to British obligations under the North Atlantic Treaty . . . .[86]

The paper then examined the implications of atomic bombs and other new technology on warfare. The justification for an offensive defense is contained in the phrase, "in the foreseeable future [there will be] no effective defence against atomic air attack. This conclusion carries the gravest implications for the United Kingdom."[87] Thus, "the primary deterrent must be the knowledge on the part of the Kremlin that any aggression on their part will involve immediate and crushing retaliation by the long-range Air Striking Force with the atomic weapon."[88] Britain must have some part in creating this deterrent in order to hit targets essential to the U. K.'s defense interests such as enemy-long range bomber airfields and submarine pens, which the United States could not be relied upon to undertake with the same vigor. Furthermore,

> we feel that to have no share in what is recognised as the main deterrent in the Cold War, and the only allied offensive in world war, would seriously weaken British influence on American policy and planning in the Cold War, and in war would mean that the United Kingdom would have no claim to any share in the policy or planning of the offensive.[89]

The idea of an independent British atomic deterrent has deep roots. The strategic concept of deterrence is an outgrowth of earlier British policies. Before World War II, naval policy was often couched in terms of deterrence. Even more important, the R. A. F. sought to deter France and then Germany in a policy very similar to what she adopted after 1945 against the Soviet Union. Realization of Britain's unique vulnerability to atomic attack narrowed its military options, as did uncertainty about American strategic priorities. The only prudent British strategic policy in the post-war years was the one it pursued, an independent nuclear deterrent. This policy had two objectives, to deter the U. S. S. R. from attacking the U. K. and to influence American policy, and it was expressed in clear and systematic terms. However, the formulation of a policy of nuclear deterrence and its implementation are two different matters altogether. The development of the

British bomb and the V-bomber would be a slow and painful process, and they would not fully meet Britain's higher aim.

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Chapter II: Acquiring the Means - Weapon

Of the two parts of a nuclear deterrent—bomb and bomber—Britain gained the former first. It developed the bomb through a remarkably successful program which overcame many obstacles. In 1945 the U. K. had no facilities for the construction of atomic bombs and little manufacturing knowledge; eight short years and a massive industrial and scientific effort later, Britain became the third nuclear power. The development of the project was slowed by the novelty of the matter, the vast complexity of the program, by Britain's strained economy in the late 1940s, and above all, by American obstinacy. British science has been fundamental to the success of the "Manhattan Project" and under wartime agreements Britain was entitled to share the technology. For several years after the war, however, the U. S. reneged on its pledges, and rejected continuous and intense British efforts to renew the wartime partnership. Without access to the theoretical knowledge or fabrication techniques developed through the "Manhattan Project", the U. K. was forced to divert its efforts to solving problems and inventing methods that already existed. All this was a waste but it also highlights the scale of British achievement. The British bomb was genuinely built in Britain, owing no more to the U. S. than the American bomb did to the U. K. The explosion of Britain's first atomic bomb in 1952 proved its technical, scientific, and potential military prowess to friend and foe alike.

The difficulty of the U. K. atomic energy program was closely tied to the extent of American cooperation. British negotiators based their efforts on close wartime collaboration in the "Manhattan Project" and two wartime agreements between the U. S. and U. K. The first of these understandings was the Quebec Agreement of 19 August 1943. Here, the driving principle was the utilization of the limited scientific and material resources of the western allies in the most efficient manner during the wartime emergency. This agreement bequeathed a critical legacy to the future British project: the governments agreed to concentrate their efforts in the United States—effectively ending atomic research in the U. K. On the other hand, the agreement stipulated that, "In the field of scientific research and development there shall be full and effective interchange of information and ideas,"[1] while design, construction, and operation of large scale plants would be regulated by *ad hoc* agreements.[2] Further, the countries agreed never to use the bomb against one another or, "against third parties without each other's consent."[3] Nor did the agreement refer only to immediate issues. It stated that decisions about post-war commercial and industrial uses of atomic energy would be decided later on terms specified by the President. To ensure smooth cooperation, allocate resources, and resolve differences, the agreement established a Combined Policy Committee. The Quebec agreement demonstrated the depth of Anglo-American cooperation and embodied the collaborative spirit the British hoped to continue.

The second important wartime agreement was the Hyde Park Aide-Memoire signed by President Roosevelt and Prime Minister Churchill in September 1944. It stated unequivocally, "Full collaboration between the United States and the British Government in developing Tube Alloys [atomic energy] for military and commercial purposes should continue after the defeat of Japan unless and until terminated by joint agreement."[4] Taken together, Quebec and Hyde Park demonstrate the depth of wartime collaboration between British and American statesmen and their hopes for future cooperation.

On the basis of these two agreements, the British had reason to expect access to information from the wartime joint program, but these instruments were not widely known even among those policy makers who had a need to know what they contained. President Roosevelt was notorious for conducting private diplomacy without keeping subordinates informed, and also for not informing his Vice President, Harry Truman, of any significant strategic issues. The American copy of the Hyde Park agreement was misfiled by a clerk who thought it referred to torpedo casings.[5] Indeed, the British had to tell President Truman of the memorandum's existence. Even the Quebec agreement, which had involved more people and existed longer than Hyde Park, was known to relatively few people. Senator Brien McMahon, chairman of the Joint Atomic Energy Committee, and an opponent of providing technical information to Britain during the debate over the Atomic Energy Act of 1946, said in 1952 that he had not known of the Quebec agreement or of the extent of British wartime collaboration until long after that debate.[6] Fewer informed policy makers meant fewer defenders of the 'special relationship.' Yet without this background, Americans naturally would wonder why the U. S. should give any information on this material to the U. K.—especially for free. Nationalism and internationalism eclipsed collaboration soon after Japan's defeat.

The first cloud over cooperation drifted into view in October 1945. At an informal press conference, Truman said that the United States,

> would not give away its engineering know-how which produced the atomic bomb to any nation . . . only the United States had the combination of industrial capacity and resources necessary to produce the bomb . . . although Britain and Canada had the blueprint of the atomic secret, they would be unable to apply the knowledge for lack of plant facilities.[7]

Attlee immediately arranged a meeting with both President Truman and Canadian Prime Minister King to clarify the atomic relationship. In November 1945, the leaders met in Washington, D. C. and produced three documents. The first was a public declaration calling for the United Nations to examine control of international atomic energy.[8] More important was a secret agreement regarding the future of Anglo-American cooperation. This short 'Memorandum of Intention' guaranteed the governments would continue "full and effective" cooperation in nuclear matters.[9] Finally, General Groves, head of the Manhattan Project, and Sir John Anderson prepared a more detailed document to guide the Combined Policy Committee in revising the Quebec Agreement. This agreement followed the lines of the 1943 arrangement with a few notable exceptions. It included Canada as a partner, removed the restrictions on British industrial and commercial use of atomic energy, replaced the requirement for mutual consent for the use of an atomic weapon with mutual consultation, and directed the CPC to revise wartime raw materials division agreements.[10] Due to timing constraints however, the leaders did not sign this document: thus, it did not hold any binding force.

Attlee left Washington with an agreement in hand that seemed to allay his fears of an end to the "special relationship," but his hopes proved false. The November agreement notwithstanding, British attempts to gain information about the production of plutonium failed in the following months. Lord Halifax's request for information on the construction and operation of atomic energy plants at a 15 April 1946 CPC meeting was bluntly rejected.[11] A heated exchange of letters between Prime Minister Attlee and President Truman ensued. Attlee's letter of 16 April based London's claim on the "full and effective" clause in the November agreement, and noted that the public declaration did not exclude the sharing of information among countries already possessing knowledge of atomic energy.[12] Four days later, Truman offered a different interpretation of "full and effective"—that it meant sharing only basic scientific information, not practical knowledge. Further, the President claimed that this interpretation was consistent with the Quebec Agreement and also the Memorandum of Intention drawn up by Groves and Anderson. More fundamentally, Truman felt that a broad interpretation obligating the U. S. to help Britain build a reactor would contradict the spirit of international control in their public announcement and undermine that prospect. Had he known how Attlee interpreted the agreement, Truman said he would not have signed it.[13]

Attlee replied on 10 May outlining the wartime agreements and emphasized the sacrifice of Britain's independent program for the common good. He hoped to continue wartime collaboration and had arranged the November 1945 conference to secure it. He rejected Truman's interpretation of the Groves-Anderson Memorandum of Intention. "I can find no support in the paragraph of that document, which you quote, of the view that there was no obligation to exchange information about the construction of large-scale plants."[14] The CPC had concluded that "full and effective" cooperation in information exchange was beneficial to both nations' programs and, "We made it clear in the discussion that our own programme would include the construction of large-scale plants in this country."[15] Attlee finished with this reminder (or perhaps veiled threat?), "We have not thought it necessary to abandon [joint control of raw materials]—in my opinion, quite rightly. Why then should we abandon all further pooling of information?"[16] Truman did not reply.[17]

Later that year, the gathering storm clouds broke and nearly drowned the struggling Anglo-American atomic partnership. The Atomic Energy Act of 1946, also called the McMahon act after its principal sponsor, prohibited the exchange with foreign powers—including Great Britain—of "restricted" information. This category included knowledge about the manufacture or use of atomic weapons, the production of fissionable material, and the creation of atomic power.[18] The damage inflicted on British interests was serious, though incidental. According to Gowing, Truman sacrificed Anglo-American cooperation for a more important domestic object: civilian control of atomic energy.[19] According to the Atomic Energy Commission's official account, Britain had little bearing on the debate over the bill. Nonetheless, the McMahon Bill was a formal barrier to further cooperation. While collaboration still continued in raw materials, cyclotrons, medical affairs, declassification policy, and American use of British scientists, these areas provided little to advance the U. K. atomic energy program: the last even drew away valuable talent.[20]

Nor was Britain able to use its strongest card to change American attitudes—raw materials allocation. In 1945-46 a major bottleneck in the production of atomic bombs was access to uranium. The wartime Combined Development Trust, which operated well into the post-war period, divided roughly evenly the world's known uranium supplies from the Belgian Congo.[21] Naturally, the embryonic British program used very little uranium compared to the American one. By 1947, the British had 3,250 tons of uranium ore (in the State Department's words) "lying idle" while American demand threatened to outstrip supply.[22] Toward the end of that year, the U. S. State Department noted the deterioration of relations with the Soviet Union, the fading hopes of international control over atomic weapons, and the increased need for American strength in this area. It also realized that while U. K. stocks of uranium had been building, the U. S. supply was inadequate to meet military needs. These circumstances were not compatible with national defense and security as defined by the McMahon Act.[23] To remedy the situation, the State Department recommended trading information for uranium.[24]

Negotiations on what became known as the "Modus Vivendi" began on 10 December 1947. The Combined Policy Committee agreed to an exchange of information on nine areas: topics already covered in a joint declassification guide, health and safety, isotopes, fundamental properties of the elements, fundamental properties of reactor materials, extraction chemistry, design of natural uranium power reactors, low-power reactors, and detection of distant nuclear explosions.[25] These areas held great promise for advancement of the British program. The agreement further specified that the U. K.'s 1948 and 1949 uranium allocations from the Congo would go to the U. S., as would part of the stockpile already in the U. K.[26] Finally, in exchange for negating limitations on the U. K.'s commercial and industrial development of atomic power, the "Modus Vivendi" revoked the Quebec Agreement's requirement for mutual consent before the use of nuclear weapons. The "Modus Vivendi" did mark an improvement in atomic relations with the U. S., but the agreement was a net loss for the U. K. In return for access to an uncertain amount of information, the U. K. surrendered much of its uranium and any claim to veto U. S. use of the bomb. In hindsight, Gowing notes, the "main reason for the talk had been to buy British accommodation in uranium at a rock-bottom price."[27] Some have criticized Britain for not demanding a higher price for the uranium, but London feared that such actions would cause Washington to harden its position on financial aid.[28] The U. K. relied on American goodwill—the rarest element of all in atomic relations.

In the event, the "Modus Vivendi" provided little information to Britain. In March, Britain formally notified Washington of its intention to proceed with atomic weapons development. Following confirmation of this aim after American visits to British reactors, one Atomic Energy Commission commissioner claimed surprise. He said that the Joint Congressional Atomic Energy Committee (JCAE) would have to be consulted before information exchange could go forward. When the British pressed for information on basic plutonium metallurgy, the JCAE Chairman, Senator Hickenlooper, insisted that the request be denied. Further requests in August and September for discussion of weapons design were also rejected.[29] The British received material regarding health, extraction chemistry, natural uranium reactors, and low-power reactors, but little directly helpful to the weapons program.[30]

Even after the disappointing "Modus Vivendi", London abided by the uranium agreement and sought further cooperation with Washington. The last negotiations before the British bomb tests began in mid-1949, at U. S. urging. The U. S. executive branch had reached a rare and fragile consensus that American and Western interests required a repair of the Anglo-American relationship and maximum efficiency in weapons production. In order to accomplish this task, the Americans wanted to combine the two nuclear programs into a single one located in the U. S. A State Department document asserted, "The best interests of the joint defense require that the major production effort be located in this country." Further, "the allocation of raw material and a fuller exchange of information would reflect this basic consideration and foster the most efficient division of effort."[31] The initial U. S. proposal suggested almost complete integration of the British and American programs. All fissionable material production, raw materials, weapon fabrication sites, and most of the finished stockpile would be in the United States. The U. K. would retain only the Windscale reactor to produce plutonium, while British scientists would be transferred to the U. S. program. In return, Britain would receive complete exchange of information and a stock of completed weapons based in the U. K. for use in agreed joint war plans. The British accepted most of the American points, but also demanded freedom to pursue new weapon designs in the U. K. assuming that it did not prevent the secondment of scientists to the U. S. Additionally, Washington would have to provide a formal assurance that the stock of weapons stored in the U. K. would be immune from future Congressional interference.[32] However, unity within the American executive branch collapsed before Britain could deliver this response.[33] Although desultory negotiations continued into 1950, "whatever hopes had existed for a tightly integrated program with the British . . . died with the Fuchs revelation."[34]

Britain felt—and was—entitled to receive atomic information discovered through the "Manhattan Project." American authorities refused to provide it for several reasons. First, they questioned Britain's physical security. It was too vulnerable to direct attack or blackmail using the threat of attack to be completely reliable. A State Department report asserted, "Our principal reason for not furnishing such information has been strategic; during the war and since, we have been unwilling to see a plant constructed close to the reach of any potential aggressor."[35] Secondly, in the early post-war period, the U. S. also feared that an agreement with Britain could undermine attempts at international control.[36] Thirdly, American authorities increasingly doubted the effectiveness of British personnel security measures. Whereas the U. S. used "positive vetting" (i. e. seeking out information about a security clearance candidate from acquaintances), the U. K. did not. Periodic atomic spy cases strengthened the weight of this argument.[37] Above all, while not formally articulated, underlying American stubbornness was the desire to retain a monopoly. Indications of this attitude appear as early as Truman's 1945 press conference and continued until the early 1950s. A 1949 State Department memorandum records, "At the present time, only the United States possesses operating production plants and weapons. Ideally the United States would like to retain its present position in the field of atomic weapons."[38] These factors combined to deny Britain knowledge which would have saved its atomic project considerable time and effort. As novel as the solutions which British authorities found to their problems, they were not new discoveries, but rediscoveries of work already done in America. From the grand scheme of the weapon, to the methods of making plutonium, to the smallest details of casting high-explosives, little was original. Britain wasted resources rediscovering techniques that could have been shared by the U. S. As the U. S. Joint Strategic Survey Committee noted in 1947, "know-how [was] 90% of the effort required to construct atomic weapons."[39]

This rendered a complex task even more difficult. The central principle behind any atomic device is criticality. If a sufficiently large amount of uranium or plutonium ('fissile' material) is subjected to extreme pressure (forming a 'critical mass') and bombarded with neutrons, the atoms split, releasing energy and more neutrons. These in turn split more atoms and release more energy and neutrons, and so on, in a 'chain reaction.'[40] While easy to describe, this process is hard to produce. Few nations have ever attempted it because it is so scientifically and technically demanding.

By 1945, two fission bomb designs had already been proven. The first, used in the Hiroshima explosion, fired two 'sub-critical' lumps of uranium 235 at one another to form a critical mass and start the chain reaction. The second method, used at Nagasaki, compressed plutonium to criticality by imploding it with conventional high-explosive.[41] Britain consciously chose to pursue the second, more complex method, because this used rare and expensive radioactive material more efficiently and held greater potential for future development.[42]

The implosion device was a complex piece of engineering in its own terms. On the outside of the bomb were firing circuits, all timed to explode simultaneously and to produce a uniform inwardly directed blast wave. If the wave is uneven, then instead of compressing the plutonium, it knocks it out of the bomb. The blast wave moves inward to the explosive shell. This shell was composed of dozens of hexagons and pentagons formed in a perfect sphere to achieve uniform compression. Further, the explosives had to be free of impurities and casting imperfections. The now intensified but still uneven blast wave moves inward to perhaps the most ingenious component. When the explosive shell detonates, each firing circuit directs the energy inward along a different line. Mathematically precise 'lenses' crafted from a combination of 'slow' and 'fast' explosives bend this energy into a single wave using shape (like an optical lens) and the different detonation speeds of its ingredients. The now uniform and intense blast wave slams into the uranium shell known as a 'tamper.' It both transfers the energy of the explosives inward and reflects neutrons back into the core making the fission reaction more efficient. The imploding tamper crushes and liquefies the fissile core composed of plutonium. The pressure wave finally reaches the component at the center of the device, the 'initiator.'

Composed of polonium and beryllium, it releases a spray of neutrons to 'jump-start' the fission reaction.[43]

In 1947, British scientists understood the theory of the implosion bomb, but manufacturing was a different story. Almost every component of the bomb involved one or more daunting challenges. The firing circuits had to fire with more precise timing than any other British bomb had done. The explosive shell and lenses demanded higher purity and more precise casting of large explosives than ever before attempted in Britain.[44] The plutonium core presented particular metallurgical problems, because its properties were almost unknown in the U. K. Unlike most substances, as it cools, plutonium changes from gas to liquid to solid at many different temperatures. Each of these phases has a different density. Thus, as it cools, plutonium expands and contracts which complicates accurate casting. Worse, both plutonium and polonium presented significant and imprecisely known health hazards.[45]

In these matters during 1945, Britain stood well behind the U. S. and in some ways behind the U. S. S. R. While the experience of British scientists who had been involved in the "Manhattan Project" could overcome some of these technical problems, their knowledge had definite limits. In particular they knew some, but far from all of the critical manufacturing techniques. During the war, General Groves had consciously excluded British scientists from production processes.[46] In 1954, he told Congress, "I was not responsible for our close co-operation with the British. I did everything to hold back on it."[47] As a consequence, in the postwar British project, both research and design went forward simultaneously. When research did not keep pace or proved incorrect, precious resources would have to be wasted in fixing the incorrect designs. That these problems were overcome without seriously disrupting the original schedule is a credit to the program.

Political and military necessity motivated the British deterrent. Even as negotiations with the Americans continued in an effort to fill the gaps in manufacturing knowledge, the design and building effort of a purely British bomb went forward. The first step in this direction was taken on 10 August 1945. A committee of senior ministers known as GEN 75 created the Advisory Committee on Atomic Energy (ACAE) under Sir John Anderson. Its mission was to advise the Government on the military and industrial exploitation of atomic energy.[48] On 29 October 1945, Attlee informed the House of Commons that on the ACAE's recommendation the Atomic Energy Research Establishment at Harwell had been created.[49] By December 1945, an ACAE report recommended plutonium over uranium 235 for both military and industrial purposes. It counselled either one or two piles depending on the amount of plutonium required for weapons production.[50] In order to address this issue, GEN 75 asked the Chiefs of Staff to estimate the number of bombs necessary to meet strategic requirements. On New Years' Day 1946 the Chiefs of Staff replied, "It is not possible now to assess the precise number which we might require but we are convinced we should aim to have as soon as possible a stock in the order of hundreds rather than scores."[51] As a consequence, the GEN 75 committee authorized the construction of two piles for a projected output of thirty bombs per year.[52] Two years later, the Chiefs refined their initial estimate and specified two hundred British bombs as the minimum number necessary for strategic purposes. They estimated that 600 bombs would be required to neutralize the Soviet Union in a war of which the United States would contribute four hundred.[53] The final important ministerial decision in this period took place at a smaller meeting of ministers termed GEN 163. On 8 January 1947, this group officially authorized development of atomic weapons and a group to accomplish it.[54]

By 1947, all three major organizations were in place to develop the deterrent. The first of these, the Atomic Energy Research Establishment at Harwell, directly contributed the least to the atomic bomb project. Its leader, John Cockcroft, was one of Britain's foremost physicists and former director of the Canadian atomic energy project.[55] He set up Harwell to explore all aspects of atomic energy. In Gowing's words, "Harwell embraced an extremely wide range of work directed to many purposes."[56] By 1952, its accomplishments included: aiding the construction organization's designs, taking the first nuclear power plant to the full-scale design stage, beginning work on a fast reactor, laying the foundation of a medical isotope industry, designing instrumentation for all aspects of nuclear technology (including the bomb), helping the weapon establishment with plutonium metallurgy and other basic scientific research, conducting health studies, performing research on behalf of civil defense authorities and the military, and serving as a center for pure academic research.[57] Although it helped here and there, weapons production did not dominate Harwell, unlike the other parts of the establishment.

The second and largest division of the atomic energy program was Christopher Hinton's building organization formed at Risley in January 1946. Unlike Harwell's primarily cerebral task, Risley's mission was to design and build the physical plant to produce plutonium for bombs.[58] Plutonium is not a naturally occurring element; it can only be manufactured from uranium through a complex process.[59] Each stage of this process required the construction of a large industrial plant. Taken together, plutonium production became a small industry in itself. Hinton brought his extensive wartime experience as a munitions manufacturer to the project. His novel management techniques incorporated very sophisticated planning and coordination between projects while simultaneously minimizing cost.[60] These tools were absolutely necessary to design and build the required facilities on schedule in economically distressed Britain, especially since in order to hasten the process much of the plant was laid down on the basis of untested predictions.

The first step in the production of plutonium requires removing uranium from raw ore and converting it into usable fuel rods. The uranium metal plant at Springfields produced its first uranium by October 1948, two years after it was first conceived. The design overcame many obstacles, not the least of which was spotty theoretical knowledge. For example, Risley based construction of a filtering complex on a small series of experiments with a ½ inch of sludge in a 2 ounce bottle. Other challenges included refining the uranium to a purity higher than ever before used in a heavy industrial process in Britain, handling a radioactive material in industrial quantities, and casting flawless fuel rods. Through research help from Harwell and tight management, the plant was a success.[61]

The next step in plutonium production is a controlled fission reaction which generates plutonium through radioactive decay of uranium. The very first small scale 'pile' was the 'Gleep' research reactor at Harwell. Using experience gained in 'Gleep,' Risley built the larger 'Bepo.' This provided new challenges in instrumentation, the handling of radioactive fuels, maintaining an unprecedented degree of cleanliness in an industrial enterprise, machining graphite on a large scale, and producing an extremely dense and uniform concrete biological shield.[62] This design in turn was scaled up to form the larger production reactors at Windscale. The construction of Windscale employed 5000 laborers and a staff of over three hundred architects, engineers, and surveyors at a time when building labor and expertise was in heavy demand for housing and conventional industry.[63] The process of scaling up the Bepo design also had to overcome the 'Wigner effect,' an unanticipated volumetric expansion of graphite when exposed to radiation.[64] Coping with this and simultaneous problems with filters nearly caused the chief design engineer a nervous breakdown.[65] Even though Windscale and the chief design engineer survived this experience, their problems were not over. In July 1950, Harwell informed Hinton that due to a miscalculation, the pile would provide 1/3 less power than anticipated. In the event, the first pile did perform at 2/3 of its expected rating, but the second reached 90%.[66]

Next, the plutonium was extracted from the uranium and other fission products at a chemical separation plant. Like the uranium metal plant, Risley based its initial design for this process on small scale experiments, in this case with only twenty milligrams of plutonium.[67] Again, the main scaling up of the original design created major problems—doubts about the research and the late completion of 'hot' lab facilities at Harwell. Meanwhile, uncertainty about the design was increased by a lack of plutonium to experiment on.[68] Ultimately, however, the plant began operations in February 1952 and proved to be 12% more productive than originally anticipated.[69]

The final step in the whole process was the plutonium purification plant. Risley quickly built this plant at Windscale, based on a complex process which was only fully tested partway through production in a pilot run at Harwell in December 1951 using Canadian plutonium. This method was then adapted to large scale production. Despite problems with both safety and output, the plant produced its first impure plutonium billet at the end of March 1952 and managed to meet the bomb project's needs.[70]

The design and development of each of Risley's plants presented problems, which often spilled over from one to another. In 1949, major and minor difficulties in nearly all of them threatened the survival of the entire weapons project. The chemical separation plants was held back by a lack of data, and when the data arrived it indicated that the foundation was too small and required modification. Simultaneously, the graphite piles were redesigned twice, serious flaws in the concrete biological shield had to be repaired, asphalting in the cooling ponds proved defective and uranium production at Springfields fell behind schedule. All these problems forced Hinton to tell the Government that Risley could not meet its deadlines without significant help. Ministers authorized higher pay to attract better labor, granted Hinton more local administrative control, and placed a permanent Ministry of Works staff at Windscale to aid in construction. Risley also secured a small applied research department separate from Harwell. These measures, and help from Harwell on the chemical plant, ended the crisis.[71] Even so, it demonstrated the interconnected fragility of the entire program.

Risley's effectiveness is demonstrated by the criteria of timing, cost, and smooth operation. Hinton kept the project on schedule. The first pile went critical within ten days of the date defined two and half years before. While the first irradiated slugs were ready by February 1952, not July 1951 as estimated, the weapons establishment was not ready for them before the actual delivery date. The financial criteria also reflects well on Hinton and his staff. Springfields cost within 10% of its estimate and Windscale only went 7% over budget. Hinton's management methods and careful supervision allowed Risley to hand back £750,000 of its £14 million estimated budget. While not perfect, for the most part the plants met the third criteria, smooth operation. They produced materials of sufficient quality and quantity for weapons establishment needs. Through improvised and invented techniques Hinton built a large industrial enterprise to handle highly complicated problems on time and under cost. This was an impressive feat of management and technology, and it had major strategic consequences.

Risley's plutonium went to the third and final division of Britain's early atomic energy program. The January 1947 ministerial decision authorizing an atomic weapons production program created the Basic High Explosive Research (BHER, later HER) division of the Armament Research Department at Fort Halstead. This organization, under Dr. William Penney, developed, built, and tested the nuclear device. This task gradually expanded to include exploration of atomic weapons effects, ideas for advanced weapons, the manufacture and proof of components, the defining of standards for and the carrying out of inspections of other agencies, proving the prototype, creating instrumentation for the trials, and producing many components for the service weapons.[72] Research into the weapon was concentrated at HER instead of Harwell for security, speed, and safety.[73]

The design and development of each of these weapon components posed numerous problems. In order to minimize these difficulties, Penney kept the British design as close as possible to the Nagasaki bomb, because that was both proven and known to the HER scientists who had worked on the "Manhattan Project."[74] Even with these advantages, enormous difficulties had to be overcome. The first major component, the high explosives which formed the device's outer shell, required then unequaled purity and precise tooling. Simultaneous detonation required exquisitely sensitive instruments to time the explosion.[75] Due to difficulty in achieving the necessary quality, only two full assemblies and one reserve were fabricated by the time of the final test. Imperfect machining still forced HER to fill the gaps between pieces of explosive shell with adhesive tape.[76] Nonetheless, the first satisfactory assembly was ready by March 1952.[77] Despite a very high rejection rate, because the explosive lenses suffered from shrinkage during casting, the Royal Ordnance Factories provided enough through mass production to meet the defined needs.[78]

Nor did this end the problems. The 'triagtrons' at the heart of the firing circuits displayed what their designers termed the 'Tuesday' effect. They worked flawlessly most of the time, but very occasionally would fire prematurely. Swansea University helped HER find a solution, but only in early 1952 did the technicians design an adequate replacement. It was rushed through development, testing, and manufacture from March to May 1952.[79]

Radioactive components proved as troublesome as high-explosive ones. While the uranium tamper was comparatively simple to manufacture, HER still could not completely eliminate porosity or surface imperfections during the December 1951 casting. The flaws were plugged and machined until adequate for the test. The production of plutonium was hampered by metallurgy, the handling of a large quantity of hazardous material, and the invention of measures to avoid premature criticality and a deadly burst of radiation when the two halves of the core were joined. When HER created the first casting of the core, it was disappointingly porous, but that problem disappeared when the metal was compressed in the dies. Once Harwell and Windscale overcame potential health hazards, they produced enough polonium for the other radioactive piece, the initiator.[80] The fact that the detonators were the only major component ready by March 1952, seven months before the test, shows the close timing of the entire program.[81]

Despite many problems in individual components, the largest and most threatening to the original schedule arose from a flaw in the overall design. During 1950, studies indicated that arming the service weapon during flight by lowering the core into it might trigger premature criticality. Because HER did not know what the American solution to this problem had been, it was forced to change the weapon's design away from the comfortable and tested Nagasaki model. Penney did so by moving the tamper away from the core. This allowed for a more efficient transfer of energy than the original design, but it was also more sensitive to flaws in the implosion wave, necessitating even greater care in manufacturing. Penney's new design may have involved other changes, but the full extent of these has not been released.[82] Here, as in so many other places, American design experience could have saved time and effort, but it was unavailable.

However great the technical and scientific challenges, manpower was HER's largest and longest lasting problem. Penney's first management plan, drawn up in 1947, required 220 men during the first two years, but this number exploded as did the number and complexity of the tasks.[83] By mid-1948, Penney needed 500 men. They were hard to find because he noted, "'The two prime requisites of skill and silence . . . make difficult the assembly of sufficient numbers of people.'"[84] Lord Portal, the Ministry of Supply's Controller of Atomic Energy, asked the cabinet to force the Ministry of Supply to provide adequate staff. Ministers replied by creating the Atomic Energy (Defence Research)

Committee, also known as the 'cake-cutting' committee. This group found that only four of the eighty-eight recruits requested by Penney were then being transferred to HER. They directed fifty-three more Ministry employees be moved along with eleven from outside the Ministry. Civil Service entry candidates filled the balance of HER needs.[85]

HER's original mandate to manufacture only the conventional explosive parts of the bomb expanded further in mid-1948 when Penney agreed to, "design and build the facilities needed to handle plutonium, polonium and uranium, as well as to design the weapon core itself and create the team which would make it."[86] This accelerated HER's manpower needs. Despite the cake-cutting committee's efforts, by June 1949, Penney still needed seventy-five more scientists within the next three months and forty-five later on. Here, Britain was running up against the ceiling of the pool of skilled scientists available for government service. Other defense research projects were short approximately 1300 men, disrupting radio and guided weapons research and threatening gun research.[87] A crisis broke in 1950, when HER and ARE separated. Not only did Penney lose his influence as the head of ARE, but the new head of ARE fought to keep many of HER's top scientists for his own projects. Meanwhile the new Ministry of Supply Chief Scientist Harry Garner demanded eight senior scientists and several junior ones.[88] This dispute was taken to the highest levels, proof of its significance. The Chiefs of Staff agreed that supplying HER's every demand had stripped bare other important defense programs. They even recommended placing several conventional programs on a higher priority than the atomic bomb.[89] HER replied that the atomic weapons project could not be slowed down without destroying it. Given the size of the proposed top category, the atomic bomb would *de facto* hold a low priority even if it nominally had a high one. Consequently, the best staff members would go to other projects, universities, industry, or even to America. Further, the resulting slowdown in research would reduce the chance of restoring the exchange of information with the U. S.[90] Minister of Defence Emanuel Shinwell resolved the problem when he accorded guided and atomic weapons and nothing else a top priority. In accordance with the new directive, Garner demanded thirty—1/10th—of Penney's staff for guided weapons research. Had HER lost these people, including fifteen senior scientists, the effect on a staff already forty under strength would have been catastrophic. The fighting ended only when the Ministry of Supply's Permanent Secretary transferred one senior scientist and four junior ones from HER.[91] This crisis demonstrates how precious skilled scientific manpower was in the Britain of the late '40s and early '50s. However small HER's demands were in an absolute sense, they were large in a marginal one, and the loss of only a few key men threatened delay or cancellation of critical defense projects. Here, Britain's gain in atomic weapons was directly subsidized by a loss in guided missiles.

Despite all of these technical and manpower problems, Britain's first atomic device was ready by the middle of 1952. Only the test remained, and Penney had decided what sort of test he wanted several years before. At the U. S. 1946 Bikini atoll trials, he witnessed a phenomenon known as 'base surge.' When an atomic bomb is exploded at or near the surface of a body of water, the mushroom cloud is heavier than a comparable air burst. As the water settles back to Earth, it carries large radioactive concentrations to a wide area around ground zero, potentially causing massive casualties. Penney wanted to study this more closely because he feared that Britain's large ports, especially London, were vulnerable to such an explosion from a bomb smuggled into the port onboard ship.[92]

Once Penney determined the type of test, finding an appropriate location remained. Obviously, testing the device in the Home Islands was impossible, so Britain searched overseas. London approached Washington on the matter and the U. S. offered use of its Nevada test facilities. The U. K. ultimately rejected the proposal because it would not give the necessary information on a shallow water explosion, McMahon Act restrictions might prevent the British from gathering all the data they wanted from their own device, and the instability of the American political system in an election year might interfere.[93] Penney rejected another site in Churchill, Manitoba because the sea was too shallow and the weather inappropriate for an October test.[94] The site considered and ultimately adopted was also the most remote. On the Chiefs of Staff recommendation, the Government received permission from Australia in May 1951 to use the Monte Bello islands for Operation "Hurricane."[95]

The high-explosive portion of the device left the U. K. on board the HMS *Plym* on 8 June 1952, escorted by a small task force centered around the aircraft carrier HMS *Campania*.[96] Despite a culture clash between the scientists and naval personnel during the trip, the ships and crew arrived safely at Monte Bello after a fifty-nine day trip.[97] The radioactive core arrived by air on 18 September.[98] The scientists set up the plethora of recording devices they needed for the test and held a limited rehearsal on 12 September and a more general one several days later.[99] During these trials, the HER staff overcame problems with both their own equipment and also with poor naval planning which led to inadequate transportation between the ships and islands. This last difficulty led HER's test director to comment, "It seems incredible that the whole of this expensive operation should hang on the thin red line of 3 or 4 [landing craft] but that is, I fear, the grim truth."[100] Once these problems were overcome, the weather became the only remaining obstacle. The test required low altitude winds to blow away from the task force while high altitude winds blew away from the mainland.[101] Meteorologists predicted appropriate weather for several days in the first few days of October.[102] Final preparations began on 2 October, D-1 day, and continued for a full day.[103] At 9:29AM local time on 3 October 1952, Britain became the world's third nuclear power.[104]

The "Hurricane" device lacked a ballistic casing and was therefore not a deliverable nuclear weapon. This matter was already in hand. The R. A. F. had issued Operational Requirement 1001 on 9 August 1946 for an atomic bomb weighing not more than 10,000 pounds, 290 inches long, 60 inches in diameter, suitable for release from 20,000 feet to 50,000 feet at speeds from 150 knots to 500 knots. These dimensions were incorporated into the medium bomber design specifications.[105] The Royal Aircraft Establishment at Farnborough carried out design work and ballistic trials in 1950 using an Avro Lincoln.[106] The "Hurricane" assembly was mated to the ballistic case producing the 'Blue Danube Mark I.' The first of these weapons was delivered to the Royal Air Force on 7 November 1953, raising Bomber Command's striking power far beyond any it had at the end of World War II—if it could only reach its target.[107]

Britain's atomic bomb project was remarkable in many ways. This was a British version of the "Manhattan Project" run by the seat of the pants and the skin of the teeth. It managed with fewer resources than either the American or Soviet programs which preceded it. Perhaps the most astonishing thing is that the program was successful at all. Its vast complexity made it inherently error prone, and any one mistake could have had a great ripple effect. A small problem in design could have thrown off plutonium production, errors in casting the high explosives could have forced a delay in the trial, even a shift in the wind at Monte Bello might have forced several months suspension. The combined efforts of Risley, Harwell, and HER—and no small measure of luck—ensured that those errors which did happen did not undermine the project.

Beyond hard work and luck, the overriding priority granted to the project helped it to get first pick of the resources of a weak economy. In 1946, the project's members found that even though it was supposed to be carried out as quickly as possible, they were de facto subordinate to housing, coal mining, and exports. To remedy this, the Prime Minister wrote a minute to the relevant ministers stating,

> I regard the development of our atomic energy project as a matter of the highest urgency and I am anxious that it should proceed as rapidly as possible. . . . I should be glad therefore if you would issue instructions to your officers . . . that everything possible should be done to avoid delay in meeting the needs of the atomic energy programme. If any conflict arises with other high priority programmes which cannot be resolved within the limits of this directive, I should be glad if it might be reported to me.[108]

Unfortunately, this directive was both a personal minute and top secret. While it could help the program on the biggest of issues, it could not be used in day-to-day operations, and it was precisely here that the problem lay.[109] Other Ministries put elements of the atomic program second to their own projects. For example, the Ministry of Health and Ministry of Labour decided that the directive did not apply to staff housing for the atomic energy project, only to the project itself. Only after "tortuous negotiations" was the housing built.[110] Such fights over men and material continued for the duration of the entire project, but direct Prime Ministerial interest continued to back it.[111] According to Gowing, the priority failed in only one respect—raising both HER's and Risley's civil service salaries to a level where they could attract and retain the skilled scientists and engineers which they needed, but who could and often did go to higher paying jobs in industry. Even if applying the directive in practice proved harder expected, and did not relieve those running the project of all their concerns about resources, there is no doubt that preference gave the project a significant boost.[112]

Britain's early atomic energy program was remarkable simply for succeeding. For a total of roughly £150 million, equal to only 10% of all defense spending in the single year of 1948, the U. K. acquired the first part of a credible deterrent.[113] Despite the weakness of its economy and little American help, Britain proved her scientific, engineering, and potential military strength. German Professor Otto Hahn expressed the British achievement succinctly when he said, "The production of an atomic weapon presupposes such enormous equipment for research and manufacture that it is a brilliant success for a country which does not dispose of the monetary and material wealth of America or the Soviet Union."[114] The successful test also sent a signal to friends and potential foes—Britain was once again a power to be reckoned with. Australian General Sir Horace Robertson said, "the possible trouble-makers . . . will realise that Britain always has some powerful card up her sleeve."[115] To play that card, however, Britain would need a delivery system.

Notes

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[6] Andrew J. Pierre, Nuclear Politics: The British Experience with an Independent Strategic Force 1939-1970 (London: Oxford, 1972), 118.

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[14] USNA, RG 59, S/AE, Prime Minister Attlee to President Truman, 10 May 1946.

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[16] Ibid.

[17] Pierre, 117.

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[20] Ibid., 112.

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[26] Ibid., 282.

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[29] John Simpson, The Independent Nuclear State: The United States, Britain and the Military Atom (London: Macmillan, 1983), 80.

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[31] USNA, Department of State Records, RG 59, S/AE, "Procedures for Tripartite Negotiations," 12 September 1949, 5.

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[55] Gowing II, 5.

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[58] Pierre, 122.

[59] Gowing II, 517.

[60] Ibid., 343.

[61] Ibid., 373-6.

[62] Ibid., 380.

[63] Ibid., 389.

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[75] Ibid., 54-5.

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[77] Cathcart, 167.

[78] Ibid.

[79] Ibid., 168.

[80] Gowing II, 466-70.

[81] Cathcart, 166.

[82] Ibid., 140.

[83] Ibid., 57.

[84] Ibid., 58, 60.

[85] Ibid., 61.

[86] Ibid., 91.

[87] Ibid., 95-7.

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[95] Gowing II, 479.

[96] Cathcart, 183.

[97] Ibid., 196.

[98] Ibid., 211.

[99] Ibid., 226.

[100] Gowing II, 491.

[101] Cathcart, 238-9.

[102] Ibid., 244.

[103] Ibid., 245.

[104] Ibid., 253.

[105] Wynn, 18.

[106] Ibid., 87-8.

[107] Ibid., 92.

[108] Gowing II, 39.

[109] Ibid., 40.

[110] Ibid.

[111] Ibid., 41-3.

[112] Ibid., 44-5.

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Chapter III: Acquiring the Means - V-Bomber

> If we want to remain a Great Power, with all the political and economic advantages inherent in that position, we must be prepared to pay for it. And part of the price is a Bomber Force, small by last war numerical standards, but of first-rate quality. - Sir John Slessor[1]

An operational nuclear deterrent requires both a working nuclear device and a reliable method to deliver it to a target. This vehicle must be able to survive any pre-emptive strikes, penetrate the enemy's defenses, and deliver the weapon with the accuracy required. With the October 1952 Monte Bello test, Britain had the first part of an operational deterrent. The equally critical second part, a credible delivery vehicle, did not exist until 1955, and it was not completely deployed until 1960. The long delay was primarily due to the difficult design processes of the "V-bombers." The complexity of the medium bombers heavily taxed the capabilities of Britain's aeronautical industry. So did the Air Staff and the Ministry of Supply, which repeatedly modified the operational requirements and the resulting specifications, forcing each aircraft to pass through a tortuous refinement process. The V-bomber program eventually did produce aircraft which met these design demands, but the latter proved inadequate to meet Britain's needs. Thus, the V-bombers required a continuous series of updates to retain any ability at all to penetrate Soviet air defenses. Andrew Pierre captured the seeming futility of that process when he wrote that the medium bomber force was unendingly engaged in a, "melancholy struggle against obsolescence."[2] The V-bomber story is one of expectations that were too high, challenges that were too difficult, and time that was too short. Before the V-bombers' arrival, Bomber Command had little strategic value and it did not have much after it. When the aircraft finally came into service, their warfighting capability was marginal at best, and it remained there despite the R. A. F.'s attempts to bolster it. Bomber Command's deterrent value fell as swiftly as the sophistication of Soviet defenses rose.

State-of-the-art military aircraft depend on the latest technology and aeronautical engineering underwent one of the greatest revolutions in its history after the Second World War. Aircraft design firms faced not one or two mild innovations, but instead a sea change in all forms of technology, ranging from electronics to engines, airframes, and wings. Before and during the Second World War the British aeronautical industry produced aircraft as effective as the Spitfire and Lancaster and afterward it remained large and advanced, but still it struggled to keep up with these developments. It took years for designers to understand fully the potential of these technologies and incorporate them in their product. As the Royal Aircraft Establishment (RAE) stated in 1949, "Pure jet engines, swept-back wings, the possibility of supersonic speed and the achievement of high-altitude flight over great ranges are all unknown quantities, and it is too early to predict how they will affect future aircraft design."[3]

Jet engines, for example, were one area in which the post-war British industry was at the forefront. Experimentation before the war had led to the first flight of a British jet fighter in March 1943 and Britain had jet aircraft in service before any other country.[4] Germany's collapse left the U. K. ahead of every other country — including the United States — in this critical technology.[5] In order to develop it after the war, British firms conducted research and development in a host of technologies from fluid dynamics to metallurgy. During the development of the medium bomber force, Britain's engine industry continued to make large strides forward in design. While the first Vulcan prototype flew in 1951 with Rolls-Royce Avon engines which generated 6,500 pounds of thrust, the final Vulcan B Mark Is flew in 1954 with Bristol Olympus 104 engines which generated 13,000 pounds of thrust.[6] British engines were at least as good as their American counterparts, and superior to Soviet rivals.

The British lead in engine technology was not matched in all areas of aerodynamic research. The swept-back wing was another wartime innovation which revolutionized the design of military, and later civil, aircraft. As an aircraft approaches the speed of sound, some portions of the airflow over the wing reach the speed of sound before others, due to the shape of the wing. This produces increased drag, decreased lift, and buffeting.[7] Sweeping the wing (i. e. placing the wings in a position where their tips are closer to the rear of the aircraft than their roots) at a large angle can significantly reduce these problems, but in order to do so one must overcome other obstacles, such as high stalling speeds which complicate landing, control problems, and extra bending and twisting stresses.[8] While the solutions to these problems are well known today, they were uncharted territory in 1945. The R. A. F. and the V-bomber designers needed the extra performance edge provided by the sweep wing, but they also had to face the design problems inherent in the technology, and another problem as well. According to Richard Worcester, the U. K. spent too much time on straight winged designs in the mid-1940s and so fell behind in this research. "It became progressively harder thereafter for Britain to overcome the cumulative effects of this early mistake."[9]

These and other technologies revolutionized aeronautics in the post-war years. If only one or two of these developments had occurred, they could have easily been incorporated into new designs, much as all-metal monoplane aircraft had gradually become the norm during the interwar years. After 1945, however, many technologies matured simultaneously, and the advances in one affected those in the others. Engines with a higher thrust might produce higher speeds, but they also stressed airframes and demanded more advanced wing designs. Developments in one field pushed advances in others so far that the, "only component common to both the Handley Page Halifax and the Handley Page Victor was a rubber bung."[10] The degree of fundamental innovation required and the frequency of changes in details led to longer lead-times, increased expenditure, and manpower-intensive research and experimentation. In one historian's phrase, "The best was very much the enemy of the good."[11] Revolutionary technological change and unforeseeable technical problems created serious problems for the V-bomber program, nor were these the only obstructions.

Another force that shaped the V-bomber program was economics. In the five years after the end of the Second World War, the British armed forces underwent dramatic cuts. In 1945, Bomber Command held 1,463 Lancasters and Halifaxes. By 1947, as the V-bomber program took shape, this number had shrunk to 157 aircraft in fourteen squadrons of Lincolns, and eight of Lancasters.[12] And in that year, the Minister of

Defence A. V. Alexander directed the Chiefs of Staff to make even deeper cuts. A memorandum of October 1947 by the Minister — part of a longer debate which had started in 1946 — outlined a defence policy that shaped the entire development of the V-bomber program. It put economic and industrial recovery ahead of planning for a major war, on the grounds that without the former victory could not be achieved in the latter. It also assumed that the Soviets would neither develop the atomic bomb nor consciously threaten vital Western interests in the near term. Therefore, "it must be accepted that an annual expenditure of £600 million will be the maximum allowed to the Armed Forces, including expenditure on production and defence research, for an indefinite period."[13] Further,

> the risk of a major war is ruled out during the next five years, and . . . the risk will increase only gradually during the following five years. . . . If attacked, we must fight with what we have. . . . Priority must be given to the forces which in peace give the best visible show of strength and therefore have the greatest deterrent value. . . . Long-range research and development would have high priority in defence expenditure.[14]

All British defense planning, including the deployment of the medium bomber force, was based on this target year of 1957. The consequences for the development of leading edge weapons were obvious. Alfred Goldberg wrote, " . . . the nation did not have the resources, especially during the years of austerity after 1945, to carry out cyclical re-equipment of her armed forces at as fast a rate as could the two super-Powers."[15]

Defense spending took a back seat to other sectors of the economy immediately after the war. As Chief of the Air Staff Sir John Slessor later commented, "Defence attracts no votes — I am afraid that is the answer. Have a well-housed, well-fed, semieducated people, but do not worry about defending them."[16] Within defense spending, moreover, the V-bomber's relative priority shifted several times over the life of the program. Before September 1949, guided weapons systems and the atomic bomb project were the only military programs with special priority. Then the Prime Minister directed bombers to the second rung on the precedence ladder, at the same level as atomic weapons. In the summer of 1950, bombers once again slipped off the special attention list.[17] Churchill's rearmament program in 1952 moved them back again to the "super-priority list," but this change had only a limited effect due to the number of programs which were simultaneously accorded this status.[18] While throughout the middle 1950s the Air Ministry and the Ministry of Defence both urged that a V-force of 240 bombers at least was needed to impress the Americans and deter the Soviets, for reasons of finance the government never authorized the force even to reach that strength.[19] Lack of priority in a struggling economy complicated an already difficult challenge and left Britain with obsolescent aircraft in the meantime.

Had war come before the R. A. F. deployed jet aircraft, Bomber Command would have faced it with two designs from World War II: the Lancaster and the Lincoln. The Lancaster was the finest heavy bomber produced by the United Kingdom during the war, and one of the best produced by any state. The Lancaster I entered service in 1942 with a maximum speed of 275 miles per hour and a 1,660 mile range; it could strike targets deep in Germany with a bomb load of 14,000 pounds.[20] Between 1942 and 1945, 7,400 Lancasters of all marks rolled off the assembly lines.[21] As the war progressed, Avro continued to produce newer and better marks of the Lancaster. The final versions, initially dubbed the Lancaster IV and Lancaster V, were renamed the Lincoln I and Lincoln II. The Lincoln, powered by four piston engines just like its predecessor, could reach a maximum speed of 290 miles per hour and carry its 14,000 pound bomb load 2,250 miles at a maximum altitude of 22,000 feet — a markedly better performance than the Lancaster.[22] The Lincoln was intended for the conventional bombing of Japan, a war which was over by the time it reached the front line. It was then pressed into an entirely different role, nuclear deterrence in the Cold War.

These aircraft had to service extensive commitments, but they were too few in number to meet the danger and their performance did not meet the need. In particular, the very characteristics which had made the Lancaster perfectly suited to war against Germany —heavy bomb load combined with short range—became a fatal handicap for the Lincoln. The Lincoln did not have the range necessary to carry out bombing missions against targets in the Soviet Union. The distance from London to Moscow is approximately 1,300 miles, and it is even further to Soviet industrial concentrations in the Ural Mountains. As the Secretary of State for Air wrote,

> . . . existing bomber types, the Lincoln and Lancaster, fall far short of the performance required; the radius of action of the Lincoln is 950 nautical miles, its ceiling is 25,000 ft., and its cruising speed about 200 knots. The performance of the Lancaster is, of course, considerably inferior to this.[23]

Here Britain's position between 1945 and 1950 was worse than that of the superpowers. The Soviets had access to airbases in their zone of Germany (about 400 miles from London) and an aircraft designed to provide far greater range than that— the

B-29 in the form of the Tupolev Tu-4. By 1949, according to one Western intelligence estimate, they had some 1,050 in front line units.[24] The Americans had even better aircraft at their disposal. In addition to the B-29, Strategic Air Command's inventory included an upgraded model of the Superfortress, the B-50, and the Convair B-36. Unlike the Lancaster and Lincoln, all of these American bombers from the beginning were designed to emphasize a fundamental requirement for bombers in the early Cold War, long range. The B-36 began development in 1941, when Britain's survival was in doubt, with the aim of bombing Europe from U. S. bases. With the U. K.'s survival secured, development slowed but then hastened again in 1943 for possible use against Japan. The prototype first flew on 8 August 1946 and entered service on 28 August 1947.[25] Both the B-36 and B-50 were developed for use in long-range strategic bombing missions and were readily adapted to their new enemy. By comparison, the R. A. F. did not have the U. S. A. F.'s ability to adapt designs already in progress to the Cold War. Moreover, in order to meet these needs, the British aeronautical industry attempted to design new aircraft with double the range of anything it had ever produced before.

The confidence of the 'no major war within five years' assumption of 1946 eroded into uncertainty by 1948 and the opening of the Cold War. Bomber Command faced these circumstances with a force unable to carry out its theoretical role of strategic bombardment. The R. A. F. took two routes to deal with this problem. The long term approach was to develop bombers on the leading edge of design for service by around 1955. The immediate approach was to find an interim solution to meet needs until that date. This program, which will be detailed later, was the attempt to put jet technology on an essentially pre-jet airframe. The failure of this aircraft, the Short Sperrin, led the R. A. F. to acquire U. S.-built Boeing B-29s. While the R. A. F., the Ministry of Supply, and the aircraft industry labored to create the medium bomber force, Bomber Command took steps to ensure its continued effectiveness in the interim.

The R. A. F. first formally requested the acquisition of B-29s in 1949. That year, the Secretary of State for Air argued to the Cabinet that Bomber Command was an instrument of deterrence. To be effective in that role, its aircraft must be able to reach targets in the Soviet Union. Thus, "it follows that our bombers must have a radius of action of 1,300 to 2,000 miles and be fast enough, and fly high enough, to reduce the chances of destruction by modern fighter aircraft or anti-aircraft fire to reasonably small proportions."[26] The "progressive deterioration in the international situation" decreed the acquisition of a more capable aircraft.[27] Since the R. A. F. expected its four-engine jet bombers to be available no earlier than 1954,

> During the next four to five years, therefore, we shall not have a deterrent bomber force worthy of the name, and in the event of war, Bomber Command would be unable to reach the majority of strategic targets. . . . Equally serious is the fact that the crews of Bomber Command cannot, with their present equipment, gain experience in the complicated technique of high altitude (30,000 ft. and over), long-range operations, nor can any training be given in this direction.[28]

The U. S. A. F. had already offered enough B-29s to re-equip eight squadrons, saving the expense of purchasing forty-one more Lincolns, some £1,845,000.[29] Use of these aircraft would also give Bomber Command valuable experience with high altitude, long-range flying, increase its morale, and make a valuable British contribution to the deterrent.

On 9 March 1949, the Cabinet Defence Committee examined the Secretary of State for Air's proposal and saw several advantages to it. However obsolescent from the American point of view, the B-29 was superior to the Lincoln. Given the slow deployment of the British jet bombers, the B-29s would enjoy a considerable period of service. Further, the Government would not have to construct any additional airfields for this program, so long as the U. S. A. F. moved to new airfields and left the old ones for British use. Hence, the committee approved the proposal.[30]

Bomber Command's first B-29, renamed the "Washington," arrived in the United Kingdom on 22 March 1950.[31] The first squadron to use the aircraft formed at Marham in June 1950.[32] The whole force of sixty-four bombers was completely deployed by September 1951. Features such as cabin pressurization, heating, and automatic pilot — novelties in the R. A. F. — made the bombers popular with aircrew. However, difficulties were associated with the new aircraft. The Korean War brought an unexpected shortage of spare parts and engines. Naturally, U. S. B-29 units in combat over Korea had a higher priority for these supplies than did U. K. units on the ground in Britain. This led to operational restrictions, including the abolition of flights above 26,000 feet — thus limiting the opportunity to gain high-altitude experience. The Washington, moreover, required a large crew. A standard U. S. A. F. crew comprised eleven men.[33] The R. A. F. reduced that number to eight, but this was still one more than required on the Lancaster or

Lincoln.[34] For a force in "accelerated rundown," any additional manpower burden was undesirable.[35] Given these difficulties, Bomber Command chose to shorten the Washington's tenure in British service. The run down of Washington squadrons began in April 1953 and was complete by 30 May 1954 — a year and a half before the first V-bomber entered service.[36]

The effects of B-29 service in the RAF are debatable. From the standpoint of warfighting potential, their value was small, because of the relatively small number of Washingtons in Bomber Command. In 1950, the Chiefs of Staff stated that a British strategic air offensive in 1951 would be, "insignificant owing to the comparatively short range of the Lincoln and small numbers of B.29s."[37] This situation did not change until the V-bombers arrived. However, given the demonstrated ability of the B-29 to carry nuclear weapons, the Washington may have had real psychological deterrent value. As Air Vice-Marshal Stewart Menaul wrote, "it was obvious even [to] the most naïve observers that they could carry nuclear weapons."[38] The experience which the crews received in flying high-speed, high-altitude, technologically advanced aircraft could not have but helped them in the future. That was experience that they would need if they were to realize the full potential of aircraft now under development.

Bomber Command could not and would not continue to rely on obsolescent aircraft. Indeed, it began to think about new bombers before the war ended. Sir Henry Tizard's "Ad Hoc" committee predicted the emergence of,

> . . . bomber aircraft, with cruising speeds of 500 m.p.h. at 40,000 (or perhaps 30,000) feet. . . . Their bomb load will be much the same percentage weight of the fully loaded machine as the present Lancaster. The radius of action with this load

> of bombs at 30,000 to 40,000 feet will be at least 1,000 miles in still air. They . . . will be fitted with [turbojet] engines.[39]

While not correct in all the details, particularly regarding range, the report clearly pointed to aircraft with the performance of the V-bombers. The next major step in their conceptualization was the Air Staff's definition of a formal operational requirement for a long range bomber. This requirement, OR/230, issued in early 1946, called for a very advanced aircraft — one with more range, weight, and bombload than the Lincoln, which would require fundamental changes in design including the adoption of jet engines and swept wings.[40] "[The] Air Staff require a long range bomber landplane capable of carrying one 10,000 lb. bomb to a target 2,000 nautical miles from a base which may be anywhere in the world."[41] It was to have several principal features. The cruising speed must be so high that enemy fighters able to catch the bomber would be too fast to maneuver. The bomber must be able to turn rapidly at the maximum cruising altitude without losing height or speed. That altitude must be at the extreme edge of the enemy's ground or aerial defenses. The bomber must carry warning devices to detect ground launched weapons and enemy aircraft, and defensive devices that could jam enemy guided missiles and detonate proximity fuses.[42]

The requirement enumerated other specific criteria for the aircraft. Its maximum weight must not exceed 200,000 pounds, so as to enable operations from "comparatively simple" airfields. The bomber needed a 2,000 nautical mile radius of action and should be able to reach an altitude of 50,000 feet with a 10,000 pound bomb load and to cruise at 35,000 to 50,000 feet at a speed of 500 knots. The requirement defined the dimensions of bomb loads with particular detail. The new bomber would have to carry a wide range of conventional ordinance individually ranging in size from 1,000 to 10,000 pounds, and a "special bomb" whose size was given, but whose nature was not elaborated on.[43] This is clearly a reference to an atom bomb, as these dimensions match those of the atomic bomb requested by the Air Staff in OR/1001.[44]

Especially novel in a bomber for this time period was the lack of defensive armament. "The aircraft will rely upon speed, height and evasive manoeuvre for protection against interception. It will not carry orthodox defensive armament . . . ."[45] The decision that a new bomber would not require armament was a radical departure from previous R. A. F. practice. In 1944, when OR/230 was first under discussion, a Bomber Command study concluded that future bombers and fighters would fly faster, higher, and with more weaponry than current models. In particular, "the 20 mm calibre appears to be the most suitable for Heavy Bomber defensive armament during the next 5 years supplemented by .5 calibre in the less vulnerable areas. . . . "[46] In 1946, however, the R. A. F. decided to build an unarmed bomber because heavy armament would directly reduce speed and altitude, the jet's best protection. Instead, it hoped to produce an unarmed jet bomber so fast as to outrun most jet fighters and flying so high as to be, "immune from effective interference from AA [anti-aircraft] fire."[47]

All of this called upon aircraft designers and manufacturers to develop an aircraft on the leading edge, with radical or revolutionary changes to every one of its significant subprograms. Thus, the section on emergency exits contained an unusual and difficult engineering problem. OR/230 unequivocally stated that either the complete pressure cabin or crew slots must be jettisonable.[48] As will be seen, this part of the design caused problems to and slowed the whole program.

OR/230, the requirement for a heavy bomber, did not lead directly to the medium bomber force. Instead, it was canceled. The Ministry of Supply feared that such an aircraft would be too difficult to build and too heavy for existing runways.[49] One officer involved in bomber design, Air Vice Marshal Ivelaw-Chapman, grew concerned at the increasing weight of bombers in general. He circulated two papers to the Air Staff which called for the limitation of runway sizes and of the all-up weight of aircraft to 100,000 pounds.[50] He stated,

> [An] ultra-big aircraft spells lack of mobility, limits the flexibility of the force and thus curtails freedom in applying the main attributes of air power. In other words if the trend towards bigger aircraft is not checked at some time we are in danger of creating a force of 'battleships of the air'.[51]

These papers typified the fears that were the OR/230's undoing. Although OR/230 was cancelled, however, it indicated something important— the R. A. F.'s preference for a jet bomber which was innovative in every fashion conceivable. A 1949 R. A. F. report said,

> In 1946, the choice that lay before the Air Staff was one of deciding between an armed piston-engined bomber, operating at relatively low altitudes and relatively low speeds, and an unarmed very-high-flying, high-speed jet bomber. The decision was a difficult one to make. After prolonged and careful consideration, however, the Air Staff decided in favour of the unarmed jet bomber.[52]

OR/230, furthermore, was nearly identical to OR/229, the Air Staff requirement from which the V-bombers were built, with a few important exceptions. The medium bomber was to have a radius of action of 1,500 nautical miles, weigh no more than 100,000 pounds, and be able to carry either the atomic bomb or a conventional load up to a total load of 20,000 pounds.[53] The rest of the requirement, however, was just as demanding as for the heavy bomber. In some ways this made design and manufacture even more difficult, since all of these requirements had to be met on a lighter aircraft. This was especially true because the R. A. F. implicitly expected the medium bomber to have a sweep wing design.

The Ministry of Supply issued the approved OR/229 on 7 January 1947, and requested tenders from the aircraft manufacturers.[54] Six companies — Avro, Armstrong Whitworth, English Electric, Handley Page, Shorts, and Vickers Armstrong — submitted brochures to the specification B.35/46 (which was based on OR/229). Armstrong Whitworth, Avro, English Electric, and Handley Page tendered designs and attended a Tender Design Conference on 28 July 1947. The Ministry decided to order and evaluate a model of the Avro submission, and to have the RAE examine and decide between the promising Handley Page and Armstrong Whitworth designs. On further consideration, RAE rejected the Armstrong Whitworth design.[55] In December 1947, two contractors, Avro and Handley Page, were given an intention to proceed (ITP), which marked the official start of design work.

Neither of these aircraft, however, was the first medium bomber to be designed and produced in postwar Britain. On 17 December 1946, when the Operational Requirements Committee discussed both OR/229 and OR/230, a Ministry of Supply representative suggested the development of an "insurance" bomber. The committee agreed that the unknown design problems inherent in a sweep-wing design might delay the introduction of aircraft based on OR/229. The insurance bomber was to be a more conventional straight-winged design, which the committee expected would be easy to produce, at some sacrifice to performance. It was supposed to bolster Bomber Command's warfighting capacity until advanced bombers were produced. The resulting OR/239, published in January 1947, defined the need for, "an additional aircraft built as nearly as possible to Requirement No OR229 but constructed on more or less conventional lines, so that it could go into service in the event of the more exacting requirement being held up or delayed an undue length of time."[56] The principal differences from OR/229 were: 140,000 pound weight (versus 100,000 pounds), a maximum speed of 435 knots (versus 500 knots), and a ceiling of 45,000 feet (versus 50,000 feet).[57] On 11 August 1947, the Ministry gave Shorts an ITP for their design to meet the new specification B.14/46.[58]

The resulting aircraft, first known as the Shorts S. A. 4, was dubbed the Shorts Sperrin. It was built quickly, but was an "unimaginative" design in the words of the Vice Chief of the Air Staff. The company's two prototypes did not meet the Ministry of Supply's expectations, nor did their estimated performance reach the required figures.[59] The Advanced Bomber Project Group (ABPG), a committee of Britain's best aerodynamic thinkers hired to advise the government on the medium bomber force, stated in February 1948 that, "[plausible] arguments can be put forward for replacing such an aircraft by a further advanced bomber design."[60] Morien Morgan, head of both the ABPG and the RAE's Aerodynamic Flight Section, later recalled, "We could see nothing to be said for the Sperrin, it seemed an awful botch, a very inferior article, and we didn't like that at all."[61]

The "further advanced bomber design" which replaced the Sperrin as an insurance bomber eventually became the Vickers Valiant. Vickers had originally submitted the Type 660 for consideration under the medium bomber specification, but it was rejected as being too conventional to meet the requirement.[62] After the Sperrin's failure, the Ministry of Supply gave the Vickers Type 660 a second look. In fact, it wrote a new specification, B.9/48, specifically around the Vickers aircraft.[63] This called for a cruising speed of 445 knots, a range of 3,350 nautical miles, and a height over the target of 43,700 feet. The B.9/48 was closer to the medium bomber specification than the Sperrin's B.14/47 had been.[64] The Air Staff decided to replace the Sperrin with the Valiant as an interim bomber because, in Assistant Chief of the Air Staff Air Vice Marshal C. B. R. Pelly's words, "only one type of aircraft would be required, and I feel sure that the B.9, in view of its performance, offers a far better solution to our problem . . . ."[65] The insurance bomber had in effect changed its nature, becoming an advanced aircraft in its own right. Since the Valiant could not be ready for some years, the R. A. F. turned first to the B-29 and then to the Canberra to provide some interim deterrent and warfighting capacity.

The Canberra, a first generation jet light bomber, was ill-suited to a strategic bombing role. Although originally considered for that task, the aircraft deployed by 1951 were designed for short-range tactical bombing. They lacked equipment to hit precision targets from high altitude.[66] A 1951 Bomber Command policy meeting declared that, "owing to its navigation limitations it cannot effectively be operated outside Gee cover except in visual conditions. Its role in Bomber Command has therefore been defined as bombing in support of the land battle within 250 miles of the front line. . . ."[67] Although deployed in large numbers by 1954, the Canberra could only carry 7,500 pounds to a target 500 miles away. Although later adapted to carry tactical nuclear weapons, the original Canberra was not atomic capable.[68] It provided important jet training for the future V-force, but was not a strategic asset in itself.[69]

The development of the first member of that V-force, the Valiant, was straightforward. The Ministry of Supply gave Vickers an ITP in April 1948.[70] The prototypes were identical to the design submitted to the medium bomber competition, with a slightly modified wing. For the most part, the aircraft was based on current technology. The design met its promise and was relatively easy to produce. The first prototype flew on 18 May 1951, and later participated in the Farnbourough Air Show.[71] Flight testing with this aircraft went well, until an engine fire caused a crash on 12 January 1952. Most of the crew escaped, but the pilot died when his ejection seat hit the tail fin.[72] A second prototype, with more powerful engines, first flew on 11 April 1952. Nine days later, the government ordered twenty-five aircraft, five pre-production models with 9,500 pound (thrust) Avon RA 14 engines, and twenty production models with 10,000 pound Avon RA 28 engines.[73] The first pre-production model flew on 21 December 1953, and the first production one on 4 April 1955.[74] The Valiant received its Controller (Aircraft) clearance on 13 January 1955, and No 138 Squadron was formed as the first Valiant squadron.[75] Nearly ten years after the end of the Second World War, the R. A. F. had its first atomic-armed jet bomber with sufficient range to reach the Soviet Union's industrial centers from British bases.

The Valiant's uncomplicated design and production contrasts sharply with those of the other two V-bombers, and this in turn highlights the problems in the medium bomber program. The Avro Vulcan changed radically several times during its evolution. Its first sketches showed an aircraft with a conventional tail, and very long sweptback wings. Unfortunately, this model performed poorly, and weighed 90,000 pounds more than the B.35/46 specification allowed. The designers then turned to a tailless aircraft, but this version was still 137,500 pounds. As the draftsmen massaged the wing dimensions, the Type 698 took on the Vulcan's characteristic delta shape. So as to reduce drag to an absolute minimum, Avro placed the Type 698's engines in the wing itself, not in pods, unlike American jet bomber designs such as the Boeing B-47. This tailless, delta-winged, embedded engine aircraft, among the most radical designs conceivable at the time, was submitted to the Ministry of Supply. The Ministry accepted the design with enthusiasm, and issued an ITP for two prototypes in January 1948. The Type 698 continued to evolve after the ITP, becoming somewhat less radical in design. Whereas the fuselage had almost completely disappeared inside the wing, the designers enlarged it. One short-lived version of the aircraft even moved the engines to the bomb bay, and put the bombs on the ventral fuselage![76]

The next stage of the Vulcan's development, at the Ministry of Supply's request, involved the building of several small-scale models to test the aerodynamic performance of the novel delta wing design before a full size prototype was produced.[77] This approach was intended to detect and prevent technical problems which otherwise might hamper the production of the prototypes. In fact, it created almost as many problems as it solved. The original proposal called for a single-engined Type 707 to examine low-speed, low-altitude performance while a dual-engined Type 710 examined high-speed and high-altitudes.[78] Avro, however, cancelled the latter aircraft, and modified a second Type 707 into the Type 707A to carry out the high-speed tests instead. The Type 707 first flew on 6 September 1949, and later crashed, killing the test pilot. This crash did not invalidate the overall design, but it did force construction of a new model, the Type 707B and the addition of several time-consuming changes to it. As a result of the Type 707B's flights, Avro made some changes in the Type 698 full-scale prototype. However, much of the design effort was on solving problems inherent in the Type 707B which could not occur in the Type 698.[79]

The Type 707A, still further altered in design to test new features for the Type 698, first took to the air on 14 July 1951. It flew approximately ninety-two hours by the next May. Its slow development, combined with doubts as to the availability of the powerful Olympus engines, slowed design work on the Type 698. The latter aircraft first flew, with smaller Avon RA 3 engines, on 30 August 1952 and appeared at the Farnbourough Air Show the next month. Over the next year, Avro grounded the aircraft several times to change the cockpit layout and install new Sapphire 6 engines. The second prototype, finally equipped with Olympus engines, first flew in September 1953. Heavy damage to this aircraft in July 1954 set back the development program yet again, as did the emergence of another fundamental problem.[80]

The multiple engine changes in the prototype had covered up an unexpected problem. When the second aircraft began high-speed engine trials in early 1955, Avro discovered that the wing design was prone to buffeting and stall at high speed and altitude — or rediscovered the fact. This fault had appeared during the trials with the Type 707A. It had not been solved, but neither had it been seen on the full-scale prototype because its smaller engines had been unable to reach the speeds and altitude where this problem began. Unless this problem was solved, however, the Vulcan might be limited to a 30,000 foot ceiling. Above that height, it would suffer from, "reduced range, impaired accuracy on a bombing run, and [would have] less margin for evasive manoeuvre."[81] Avro solved the problem by redesigning the wing's leading edge, scrapping sixteen already built. The new wing with a "kink", which became known as the Vulcan Phase 2 wing, was tested in October 1955 on the second prototype.[82]

The period between design and prototype had become long and tangled. The Ministry of Supply had expected two pre-prototype models to be tested simultaneously, and for these lessons to be incorporated in the full size prototype. Instead, three pre-prototype models had been tested sequentially, the 707, 707B, and 707A. The lessons derived from the first had been applied to both the second and third models and the full size prototype. Then, the third model and the prototype had been designed and built at overlapping times. And this whole process was subject to jamming halts in the design and production of all the models.

The first order for twenty-five production Vulcans was issued on 14 August 1952.[83] The Ministry of Supply ordered another thirty-two in late 1954, and twenty-four more in late 1955.[84] The R. A. F. began acceptance trials during August 1956 and OCU No 230 received its first aircraft on 18 January 1957, almost ten years to the day after the V-bomber's first tender for design.[85] Before this final entrance into service, the program suffered another fatal accident. The RAF undertook a "flag-waving" tour to the South Pacific with the second production Vulcan during late 1956. The aircraft made a substantial impression "Down Under" and an even greater one in London. On the Vulcan's final approach to Heathrow Airport in London, a combination of poor ground control, heavy fog, and an inaccurate altimeter caused the pilot to crash.[86] He and his co-pilot, Air Marshal Sir Harry Broadhurst, the Air Officer Commanding in Chief of Bomber Command, successfully ejected from the aircraft. The rear three crew members died when they did not reach the escape hatch.[87]

The design and development of the third V-bomber, Handley Page's Victor, was even more lengthy and complex than with the Vulcan. Handley Page began by examining several possible designs — ironically, it rejected the delta wing settled on by Avro as being too unstable. One model combined a high sweep with a long wing, but this led to several problems including stalling, unacceptable drag, and a tendency for the aircraft to pitch up. Handley Page's designers solved this problem by tapering the wing from the inboard section. This gave the Victor its trademark crescent wing shape, and also an internal structure which allowed a large bomb bay. On 1 January 1948, the Ministry of Supply issued an ITP to this promising design with a predicted 90,000 pound weight, range of 5,000 miles at 520 miles per hour, and ceiling of 50,000 feet.[88]

Handley Page did not have the manpower to build the entire small scale model, so it subcontracted parts of the task to Blackburn.[89] The HP 88's purpose was to explore the behavior of the crescent wing at a variety of speeds, the value of different leading-edges and flap settings, and the stability of the T-shaped tail. The model first flew on 21 June 1951, but was plagued by problems. As with Avro's Type 707s, many of the HP 88's difficulties were specific to its design, and the solutions would not assist on the real aircraft. Additionally, the model flew too late to materially affect the full scale prototype then under construction. Tragically, the HP 88 crashed on 26 August 1951, killing the pilot.[90]

Handley Page originally hoped to have the first full-scale prototype, dubbed the HP 80, airborne by 1951. However, design problems forced a delay until the Farnborough Air Show in 1952.[91] Although the Ministry of Supply signed a contract with Handley Page for twenty-five aircraft on 14 August 1952, more problems with the prototype's center of gravity (which was so far back that counterweights had to be placed in the nose cone), hydraulics, and power controls forced the delay of the first flight to 24 December 1952.[92] After one prototype was fitted with larger engines which generated 8,300 pounds of thrust, vibrations caused a flap to fall off in flight. Although the pilot safely landed that aircraft, another prototype was destroyed on 14 July 1954 when the tail fell off in mid-air. Handley Page later determined that its tests with the new engines had missed a vibration which led to tail flutter and the subsequent crash. After further redesign, the first production Victor B Mk 1 flew on 1 February 1956, with new Sapphire Mark 202 engines rated at 11,000 pounds of thrust. Handley Page delivered the first Victor to the R. A. F. on 28 November 1957 — two years behind the first tentative schedule.[93]

By that time the R. A. F. itself realized something had gone seriously wrong in its approach to the design and procurement of advanced bombers. In 1955 an examination of the development of aircraft recorded,

> Explanations or excuses which can be offered for the failure to do better are as follows:- (a) The pace of advance in the present phase of aeronautical development is extraordinarily fast; it took 50 years to reach the speed of sound; it is likely to take 10 years or less to reach double that speed. The development of each new aircraft opens up large areas in which new knowledge has to be acquired. (b) We are still suffering from the consequences of the period of disarmament after the war. Several years were lost first by the decision not to experiment with manned supersonic aircraft but to rely on models, and by our failure to provide the extremely expensive advanced test facilities such as high speed tunnels, and finally by the delay in proceeding with swept-wing fighters until after the Korean war started. (c) . . . Certain manufacturers quickly became overloaded, having regard to their technical and managerial capacity. (d) Until the end of 1953 the policy was to order a number of aircraft which was inadequate for development purposes. Only two or three of each type were available for testing whereas the number of, for example, fighters of each type needed for this purpose is about 20.[94]

The report went on to criticize the desire to incorporate the latest technology into every aircraft, organizational defects, and the lack of consequences for manufacturers who failed to meet specifications.[95]

This assessment uncovers some of the roots for the R. A. F.'s problems, but not all of them. The V-bomber program suffered from two fundamental difficulties, the sheer ambition of the designs and the poor use of Britain's limited aeronautical industry. The Sperrin was an all-around failure. The Government paid for the development of an aircraft whose design and prototypes both failed to meet the specifications, which were not overly demanding. These choices were not solely based on military considerations. The Vice Chief of the Air Staff complained in 1947, "we know that the Ministry of Supply's choice of Shorts is largely governed by their desire to give this firm an order." He argued that the Air Council should not again leave bomber selection to the Ministry of Supply, an indication that he feared a recurrence of such considerations.[96] The Chief of the Air Staff agreed, "It is unthinkable that the Defence policy of the Country, which rests primarily on the air striking force, should be determined by the desirability or otherwise of keeping one particular aircraft firm in production."[97]

On top of this, Britain divided its resources for a manned bomber between two designs and firms. Counting the Valiant, in the late 1950s Britain actually had more different advanced bombers in service than did the U. S., even though Strategic Air Command had ten times the strength of Bomber Command. The R. A. F. justified this course on practical and historical grounds—this was the way that the R. A. F. had ordered aircraft ever since it had been formed and its leading members had personal memories going back to the dawn of military aviation. In 1952, Chief of the Air Staff Sir John Slessor wrote that two B.35 models were essential for two reasons. First, no single manufacturer could produce adequate numbers of aircraft in time, but if the Government purchased both the Vulcan and Victor, there would be enough to fill the force. Second,

> one never quite knows how these things are going to turn out. Before the late war we went for 3 types of the heavy bomber of the day - the Sterling, Halifax and Manchester. I remember well in 1938 we thought the Sterling was the winner. In fact it turned out to be the least effective and a development of the Manchester (which was not very highly thought of) turned out to be the Lancaster - the best night bomber of World War II.[98]

Against Slessor's first point is the fact that by committing two manufacturers to develop and construct two complex designs, Britain was, "[tying] up the entire nation's bomber design potential simultaneously."[99] Thus, the R. A. F. might have the potential to build many bombers created to a 1946 specification, but its potential to develop more advanced models (e. g. supersonic bombers) concurrently was limited. The R. A. F.'s approach tied up a large share of Britain's engineering brainpower—especially in the aeronautical design sector—to one project, at the expense of many others—especially other military aircraft. Slessor's comment also indicates an unwillingness to question the business and organization of the British aeronautical industry, and to let the latter shape fundamental aspects of British air policy. As for his second point, between 1914 and 1945 certainly, a small firm could put out an effective aircraft, due to the simpler nature of the design and testing requirements. "Indeed, [during World War II] to get a good design it was almost held to be essential to have several different tries, and small manufacturers seemed as likely to hit the jackpot as large."[100] For a period confronting the need to create and to incorporate a host of expensive technologies ranging from radar to sweep wings to jet engines, however, small firms were much less likely to succeed. Britain reduced those chances still further by dividing its energies between several of them, wasting both time and money in the process. That fact, combined with the difficulty of the medium bomber force specifications, made the process long and error prone. Further, the Lancaster did not emerge from the development process as an effective design. By Slessor's own admission, it was an unexpected development of the Manchester. In essence, Slessor advocated the continuation of a process that had very nearly failed in the past. He also failed to realize that in a future war, there would be no time to stumble on 'unexpected developments' and that Britain could not strategically or financially afford such a haphazard process.

In some ways, moreover, the procurement system of the R. A. F. was systematically inefficient—it benefited the manufacturer whether or not the aircraft produced was successful. As a Royal Navy officer told Parliament in 1953,

> The aircraft industry is in the remarkable position of never having to back a loser, they get their money both ways — whether the aircraft works or not. There is no guarantee in their contract that their flying machine will be a success, and if afterwards it is found that a radical modification is required to the product of the industry then the customer pays to have it remedied.[101]

There was little incentive for a manufacturer to hunt down all the problems in a design before handing it over to the government.

The R. A. F. also adopted operational requirements and specifications that were extremely difficult to meet, and deliberately favored designs which were at the extreme edge of technical possibility. Both the Vulcan and Victor programs required an extraordinary amount of basic research, and research and development regimes of unprecedented complexity. All of the ancillary programs were of radical design and if any one of them failed, the whole program would be thrown off stride. In particular, each required an entire subprogram of reduced scale models in order to assist the prototype. Both the Avro and Handley Page test-aircraft programs, however, were limited in success. Lives, money, and especially time, were lost in making the technological leaps needed to meet the rigorous specifications. The subprograms still failed to anticipate problems which cost resources and time to fix in the prototypes, and in the Vulcan's case in the first pre-production aircraft.

Emergency escape facilities offer a clear example of the problems involved in meeting such advanced specifications. As early as 1946, the aircraft was supposed to have a jettisonable crew compartment. This was an extraordinarily ambitious demand. This feature appears today only in the General Dynamics F-111, but not in any U. S. strategic bombers, which have only ejection seats. Avro told the government in 1949,

> there is no doubt that the provision of [cabin jettisoning] in a manner which we feel could command both your confidence and that of those who would use the aircraft, is very difficult, and would certainly involve a considerable increase in complexity and in structure weight. . . . I am . . . concerned at the real difficulty of solving a problem of such a novel kind at the same time as the many other problems which are vital to the success of the project . . . .[102]

The only manufacturer to come close to filling this requirement was Handley Page. In 1949, it was working on a design for the Victor in which explosive bolts would fire, releasing the nose cone. Fins would then stabilize the falling cone and a parachute would deploy.[103] However, this idea was difficult to implement and the other two contractors had even more trouble meeting this requirement so the Ministry of Supply canceled it for the Valiant in June 1948, the Vulcan in May 1949, and the Victor in October 1952.[104] Until those dates, however, the complex work required for this function distracted manufacturers and design teams from other problems with the aircraft and complicated the overall design.

Beyond all this, Bomber Command's adaptation to the atomic age was affected, and hampered, by its previous victory. During the Second World War, Bomber Command was a critical arm of Britain's grand strategy, indeed for a time it was her only offensive arm. In Bomber Command's search for a post-war role, it naturally turned to its successful past. Its new role was a continuation of the old mission of deterrence. Its next generation aircraft, while more advanced than those contemplated in the 1930s, still shared one characteristic with them—they aimed at unescorted high-altitude bombing. Even the R. A. F.'s acquisition process followed earlier methods although these were not appropriate for a new aeronautical age.

Despite these problems, Avro, Handley Page, and Vickers produced three excellent aircraft which met the specifications. One-hundred and eight Valiants were produced. They could reach 414 miles per hour at sea level, had a service ceiling of

54,000 feet, and could carry its 21,000 pound bomb load a distance of 3,450 miles.[105] The first model of the Vulcan, of which forty-five were built, could reach 625 miles per hour and 55,000 feet and drop 21,000 pounds of bombs 3,000 miles away.[106] The first mark of Victor, of which there were twenty-five, had a maximum speed of 0.9 Mach, could reach 55,000 feet, and deliver 35,000 pounds of bombs on a target 2,500 miles away.[107]

The relative success of the V-bombers is best defined through comparison to the closest equivalent American aircraft, the Boeing B-47. The first design studies leading to the Model 450 began in 1943. Unlike the proposals that eventually became the V-bombers, the B-47 began life as a straight-winged design with jet engines mounted under the wing. After V-E Day, engineers who visited Germany brought back information regarding sweep wings. Boeing incorporated this innovation into the new design. A new plan, the Model 448, incorporating both sweep wings and buried engines appeared by late 1945. However, the Air Force insisted that Boeing move the buried engines under the wing to avoid vulnerability and safety problems. The Government approved the design and ordered two prototypes in May 1946.[108] The XB-47 first flew on 17 December 1947, and the first B-47A on 25 June 1950. This first production model was essentially a service version of the prototype with very few changes.[109] The B-47's performance was roughly comparable to the V-bombers: it could carry 20,000 pounds of bombs 3,200 miles, at a maximum speed of 630 miles per hour, to a height of 42,000 feet. The real difference between these aircraft lies in entry into service. The first V-bomber entered service in 1955. By 1954, 100 B-47s were already in service with Strategic Air Command.[110] This highlights the two major failures of the V-bomber program. They were indeed excellent machines, but they took too long to develop — so long, indeed, as to miss their moment. By the time they reached active service, they were already obsolescent, and so remained throughout that service. Moreover, the numerical strength of the V-force was always far below that of Strategic Air Command — so small that it denied itself any advantage of mass.

The aircraft which composed the medium bomber force were the most complex the R. A. F. had ever fielded to that date. They sprang from demanding specifications, in some ways too demanding. Their development was difficult, but once in service, they were as good as any other manned bomber. Development did not stop there. The engines, electronics, and structure of the V-bombers went through several improvements. Their weapons became ever more sophisticated. They acquired new roles such as reconnaissance and refueling tanker. Nonetheless, the primary purpose of the V-bombers, of carrying out the independent deterrent, would always be difficult — at the very edge of their capacity.

Notes

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[18] Goldberg, 616-7.

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[27] Ibid.

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[30] UKPRO, CAB 121/9, Cabinet Defence Committee, Extract from DO (49), 7th meeting, 9 March 1949.

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[32] Ken Delve, The Source Book of the RAF (Shrewsbury: Airlife, 1994), 77.

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[35] Wynn, Bomber, 4.

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[66] Ibid., 68.

[67] Ibid., 100-1.

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[104] Wynn, RAF, 142.

[105] "The Vickers Valiant," Jane's All the World's Aircraft 1960-61 (London: Jane's, 1960), 70-1; Delve, 201.

[106] Delve, 203; Jackson, 107.

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Chapter IV: Results

The early British atomic deterrent had two roles: to further political objectives with the United States and military ones against the Soviet Union. When the first generation kiloton weapons and V-bombers were deployed by the late 1950s, Bomber Command successfully accomplished its political goal. However, while of some use in concert with Strategic Air Command, the fission-device armed medium bomber force was of little independent value against Moscow.

Whatever its military effectiveness, these British programs fulfilled the goal of political cooperation with the United States. The clearest indicator of the new relationship was the 1954 amendment to the Atomic Energy Act (McMahon Act) of 1946. This allowed extensive sharing of technology and integration of strike plans—even discussions about an American supply of atomic bombs for Bomber Command. Many of these ventures came to fruition only after the more extensive changes to the McMahon Act in 1958, but their origins lie at Monte Bello. Collectively, they amounted to unprecedented actions in peacetime by the U. S.

British leaders had hoped that a successful test at Monte Bello would lead to the reopening of negotiations with the U. S. on atomic cooperation. Prime Minister Churchill reiterated these hopes in a post-test speech to the Commons in October 1952. He announced,

> We have conducted the operation ourselves and I do not doubt that it will lead to a much closer American interchange of information than has hithero taken place. . . . There are a very large number of important people in the United States concerned with this matter who have been most anxious for a long time that Britain should be

> kept better informed. This event will greatly facilitate and support the task which these gentlemen have set themselves.[1]

And the test had the desired effect. The attitudes of both the legislative and executive branches changed as a result of Britain's newly demonstrated atomic competence. Senator Brien McMahon, sponsor of the 1946 Act which largely excluded American atomic collaboration with Britain, said shortly before the test,

> The achievement of an atomic explosion by Great Britain, when an accomplished fact, will contribute to the keeping of the peace because it will add to the free world's total deterring power. This event is likely to raise in still sharper focus the problem of atomic co-operation between ourselves and Great Britain. The British contributed heavily to our own war-time atomic project. But due to a series of unfortunate circumstances the nature of the agreements which made this contribution possible was not disclosed to me and my colleagues on the Senate special atomic energy committee at the time we framed the laws in 1946. Now we may consider re-thinking the entire situation with all the facts in front of us.[2]

In March 1953, Edmund Gullion, a member of the State Department's policy planning staff, argued that the wartime agreements gave the U. K. valid reasons for believing that it was entitled to atomic information. He attributed the poor state of current relations to confusion in American decision making and also to spy cases in both programs. Therefore, he reasoned since,

> we know that the British have the bomb [and] . . . we know that the Soviet Union incontestably has atomic weapons . . . [the] reasons for the rigid restriction in the McMahon Act . . . no longer seem valid and, in fact, are possibly detrimental to our own interest.[3]

For his part, President Eisenhower claimed to be embarrassed by the treatment given the British during the 1940s. He told the National Security Council (NSC) in 1955,

> that it was 'pitiful' a few years ago when the British were desperately anxious to avoid making the same mistakes in the atomic energy field which we had earlier made. They invoked the Quebec Agreement and made all kinds of pleas, to no avail.[4]

In December 1953, the NSC urged greater disclosure to "selected allied governments" in the hope that: it would allow them to "participate intelligently in military planning," encourage them to act with the U. S. in a crisis, strengthen allied civil defense, continue ongoing cooperation with the U. S. atomic energy program, and spur continued research.[5] The report pressed for an expanded interchange of information on the effects of the weapons, the tactical and strategic use of atomic bombs, the discussion of Soviet atomic capabilities, the techniques of defense, and an exchange on wider scientific and technical issues. However, the report specifically excluded discussion about the manufacture of weapons or the total size and deployment of the American arsenal.[6] While this was not everything the British had hoped to gain, it was far more than they had managed to that point. The NSC memorandum did not articulate all the reasons for amending the act. The 1946 Act had not stopped the Soviets from developing atomic weapons, but it had slowed Western atomic research, caused a duplication of effort in the segregated allied programs, and denied NATO nations the information about nuclear weapons effects they needed to undertake realistic planning.[7] Despite all these reasons, however, it was above all Britain's atomic competence that forced this change in America's atomic policy.

The new British capacity, combined with the growing Soviet atomic threat, pushed the President to action. Even though some members of Congress called it premature—one influential member said information exchange with the U. K. was like trading a horse for a rabbit[8]—President Eisenhower asked the Congress to amend the 1946 act. While the President wished for a more comprehensive change, he only secured a limited amendment, applying mainly to the industrial and pacific uses of atomic energy.[9] Following the passage of the amended act, the two countries signed the "Anglo-American Agreement for Co-operation Regarding Atomic Information for Mutual Defence Purposes." The treaty took maximum advantage of the less restrictive law to open many previously closed fields including: the development of defense plants, training of personnel in the employment of and defense against atomic weapons, and the evaluation of Soviet capabilities for atomic warfare. Crucially, Washington signed an agreement only with London; no other ally received such sensitive information as a result of the amended Atomic Energy Act.[10] Under the agreement, the U. S. also provided the external characteristics of American atomic weapons to the R. A. F., giving it the necessary information to modify bombers for carriage of U. S. weapons.[11]

Although they were substantial, the 1954 amendments were important less in themselves than in the atmosphere of cooperation that they fostered. The new act represented an acknowledgment of Britain's progress in the development of atomic weapons and the restoration of trust between the two allies. While only the demonstration of a British hydrogen bomb and fears of Soviet ballistic missile technology would bring about the full cooperation London had long desired, 1954 ushered in a new era in Anglo-American atomic relations.

Technology sharing flourished in this relationship. After 1954, but before the first British hydrogen bomb test, the U. S. provided important information for both the Air

Force's Blue Streak Intermediate Range Ballistic Missile (IRBM) and the Navy's nuclear propulsion program. In June 1954, the U. S. government promised to help London develop its native IRBM program. As a result, Blue Streak's motor was based on the American Atlas missile and manufactured under license.[12] Similarly, the Royal Navy enjoyed the fruits of U. S. technology for its first nuclear submarines. Discussions, which began in 1956, provided the British with limited information about power plant design. Following the Atomic Energy Act of 1958 and subsequent Anglo-American agreements, the U. S. Navy transferred a complete submarine atomic reactor similar to the type used in the American *Skipjack* class.[13]

Military nuclear cooperation between the U. S. and U. K. was not limited solely to the exchange of technology. One of London's original goals had been to ensure that American targeting plans accounted for Britain's concerns. In January 1952, as the British bomb project approached completion, Churchill learned many details of the American strategic bombardment strategy. By the end of 1952, the Chiefs of Staff had received, "on a highly personal basis a great deal of information about the Plan."[14] But, however intimate the Chiefs' knowledge, it was a far cry from full coordination.

The formal process of arranging that coordination lasted several years. During a meeting between Chief of the Air Staff Dickson and U. S. A. F. Chief of Staff Twining in 1955, the former urged closer cooperation because, "Bomber Command and the Strategic Air Command will be attacking components of the same vast target complex. It follows that unless there is a full exchange of information and co-ordinated plan of attack, wasteful overlapping and dangerous omissions will result."[15] These discussions led to further meetings in 1957 where senior R. A. F. and U. S. A. F. officers set out proposals for coordinated strike plans. The new Chief of the Air Staff, Sir Dermot Boyle, told the Chiefs of Staff at the beginning of 1957 that the R. A. F. had,

> been trying for some years to persuade the USAF to begin joint planning for the use of the British and American strategic air forces. Until recently, little progress had been made, *mainly because the Americans were not willing to discuss the subject with us until we had a medium bomber force in existence*. However, earlier this year the Americans, having realised that the V-bomber force was becoming a reality, sent a team of senior USAF officers to London, to discuss with the Air Ministry the co-ordination of the nuclear strike plans of the USAF and RAF and, also, the provision of American nuclear weapons for the RAF in the event of war. At this meeting, outline arrangements for putting these measures into effect were approved, together with a concept of Allied nuclear operations and an outline plan of action for these operations.[16] [emphasis added]

As negotiations continued, the deployment of the medium bomber force went forward. In November 1957, the Minister of Defence, Duncan Sandys, approved a document entitled "Strategic Targeting Policy for Bomber Command" on a provisional basis until enough was known about U. S. plans to ensure that they provided for British interests. A series of meetings during May 1958 provided that assurance—the two air services coordinated targeting, routing, and timing, and produced a fully integrated plan. Boyle informed the other Chiefs that every target in Bomber Command's plans had also been in Strategic Air Commands'. Both governments approved the final plan on 4 June 1958, and it went into operation on 1 July.[17] Under the integrated scheme, Bomber Command had responsibility for 106 targets: 69 cities, 17 air fields, and 20 air defense sites.[18] This integration signaled the clearest success of the early deterrent. Without an atomic-armed medium bomber force, the British probably could not have gained access to and influence over American targeting plans. The small operational deterrent allowed them to sway SAC's far larger force in Britain's favor.

Simultaneously under "Project 'E'" American kiloton and later megaton weapons were put at the R. A. F.'s disposal. Formal negotiations began in March 1957 and weapon deployment started in October 1958.[19] In practice, the arrangement was of limited value and had a short life. Complex custodial arrangements hampered the timely dispersal of V-bombers armed with these American weapons, at a time when a few minutes delay in launching might lead to their destruction in war. The program was ultimately phased out as British weapons became available.[20] The significance of this program, however, lies in the unique intimacy it represented. No other country had ever been trusted to carry American nuclear weapons in its own aircraft, or has ever been so since. This was possible only because of restored American trust and a native delivery system.

The first generation British deterrent was a political success. Although it alone did not lead to total integration with the American program, it created an atmosphere conducive to enhanced cooperation. Programs which constituted the renewal of the allied nuclear project, such as integrated targeting, weapon sharing, and technology exchange, took form after Operation Hurricane and partial deployment of the medium bomber force. Thus, the first generation deterrent accomplished one of its primary goals—it caused the U. S. to honor its wartime commitments. The new relationship with the United States, opened because of London's independent progress, sustained the British deterrent into the 1990s. Technologically sophisticated Polaris and Trident would not have been given to the U. K. had it not been for decisions taken in Washington after the existence of the British bomb and the V-force. The profits generated by the first generation atomic deterrent continue to purchase strategic capability for Britain today.

On a wider strategic level, the first generation deterrent was also a stunning success. It gave the U. K. a hand in American nuclear planning and formed the capstone of the world-wide strategic alliance. It was an important factor in allowing Britain to become the most important American ally until the 1970s, and the closest even in the 1990s. This new closer relationship contributed to the kind of stable structure in the Western world Britain wanted and to the influence London wished to wield within it. The atomic bomb and the V-bombers did not create that system and this influence on their own, but it would have been more difficult to create without them.

The deterrent's political achievement with the United States, however, was not matched by its military potential against the Soviet Union. Both before and after the introduction of the V-bombers, the first generation British deterrent was of only limited use as a warfighting tool. During the late 1940s and early 1950s, when Bomber Command depended on wartime aircraft such as the Lincoln and Washington, the R. A. F. had almost no strategic capability against the Soviet Union. The V-bombers markedly increased that capacity, but only briefly: by the time they were deployed in significant numbers, enemy ballistic missiles threatened to destroy them on the ground and friendly ones to eliminate their mission. Moreover, the lack of solid intelligence on potential targets in the Soviet Union combined with the limits to the supply of weapons for Bomber Command hampered its viability as a deterrent force, while the vanishing Empire took with it the R. A. F. bases needed to wage a comprehensive strategic campaign. However, the deterrent's most daunting obstacle was time. Soviet air defenses improved in quality and quantity during the 1950s so far as to invalidate an independent Bomber Command strike.

The aircraft available to the early post-war Bomber Command were entirely inadequate for strategic operations against the Soviet Union. The Lincoln, a key component of the R. A. F.'s striking force, could not even reach most Soviet targets, nor could its speed and altitude protect it in the new age of jet fighters. In March 1947 the Air Ministry felt that to effectively bomb Soviet targets, "our bombers must have radius of action of 1,300 to 2,000 miles and be fast enough, and fly high enough, to reduce the chances of destruction by modern fighter aircraft or anti-aircraft fire to reasonably small proportions."[21] Lincolns and Lancasters simply lacked the characteristics needed to carry out that mission. These inadequacies led Britain to acquire a more effective aircraft, the Washington, but even it was not effective enough to suit the task at hand. Unlike the Lincoln and Lancaster, the B-29 was tested against a modern air defense system in the Korean War. The B-29's failure in that theater highlights the inability of Bomber Command to inflict serious damage against the U. S. S. R. during the early 1950s.

During the Korean war, B-29s flew over 21,000 combat sorties.[22] Their first opponent, the North Korean Air Force, had only 132 antiquated aircraft and little experience.[23] One American B-29 commander remarked, "We didn't have any opposition and the bombardiers had all the time in the world to make their bomb runs."[24] This situation quickly changed with the arrival of the Chinese Air Force armed with Soviet-built Mig-15 jet fighters. By June 1952, the Chinese Air Force comprised 1,830 aircraft (including 1,000 jets) and the North Korean Air Force had an additional 270 aircraft, all supplemented by 786 anti-aircraft guns, 1672 automatic weapons, and 500 mobile searchlights, early warning radars, and ground controllers.[25] Any strategic bombing campaign against the Soviet Union would have faced at least this level of technological opposition and a greater standard of quantitative strength, nor was this the only problem. Most Chinese and North Korean pilots had marginal tactical abilities. With the exception of a handful of skillful Soviet pilots, known as "honchos," Communist airmanship was markedly inferior to their American opponents and Soviet teachers.[26] In the case of an atomic offensive against Russia, enemy fighter pilots would have undoubtedly been of higher caliber. Moreover, during the Korean War, the B-29s had been protected by friendly jet fighters. These short range escorts would have been unable to assist in strategic raids deep in Russia. Hence, B-29s would have performed far less effectively against the U. S. S. R. than they did in Korea.

Not that they performed well against these modern and numerous Communist air defenses in Korea. A mission on 1 March 1951 illustrates the vulnerability of this World

War II era bomber. Eighteen B-29s flying without escort in the daytime were attacked by nine Chinese jets. The bombers closed formation and managed to shoot down one fighter and damage two more, but at great cost; ten B-29s suffered major damage. The official history laments that the bombers "were no match for the speedy jets."[27] As Communist defenses increased through 1951, B-29 losses mounted. During the last week of October 1951, the Far East Air Forces lost five Superfortresses and suffered major damage to eight more—a loss of fifty-five crew dead or missing and twelve more wounded.

As a result, the U. S. almost entirely replaced daylight bombing with nighttime "SHORAN" (i. e. radar-guided) bombing.[28] While American and Communist Air Forces competed for air superiority over the next two years, the B-29 became increasingly vulnerable. Eventually, so as to hamper interception by jet fighters, it was forced to attack defended targets only at night and in bad weather. General Fisher, commander of the Far East Air Force Bomber Command, feared that, "If the Communists ever crack that last link and get an all-weather capability of pressing an accurate firing attack, the B-29 business is really going to get rough."[29] When the B-29s shifted to nighttime SHORAN bombing, they exposed another deficiency which was fundamental to any strategic bombing campaign: accuracy dropped due to erroneous maps. It took an intensive intelligence effort of roughly a full year to adequately map a relatively small and easily reconnoitered war zone.[30]

Korea thoroughly demonstrated the obsolescence of the B-29. By the end of 1954, the U. S. A. F. had entirely abandoned Superfortresses and the upgraded B-50 model was gone a year later.[31] Yet the B-29, inadequate against modern air defenses, still remained the most capable aircraft in Bomber Command until the mid-1950s. While of some use at night, in bad weather, and over a thoroughly mapped area, the B-29 would have been nearly useless over the vast dimly known Soviet interior. Until the deployment of the V-bombers, Bomber Command's best—Lincolns and Washingtons—would not have been good enough. At best, they might have been able to destroy a few large cities: they could not even have begun to meet the counter-force strategy with which the contemporary R. A. F. was charged.

The V-bombers entered service in early 1955. However, their deployment was slow. By December 1958, Bomber Command possessed only 45 Valiants, 18 Vulcans, and 10 Victors—a total of 73.[32] Slow activation and the novelty of the aircraft hindered early combat effectiveness. In the V-Bomber's only major action in the 1950s, twenty-four Valiants flying out of Malta participated in Operation "Musketeer," the Suez campaign.[33] The Valiants suffered from several elementary deficiencies including no visual sights, NBS (Navigation/Bombing System), or (initially) clearance for high-explosive stores.[34] Nor were they effective in fairly simple conventional tasks. By the end of the operation (of which the V-bombers played only a part), three of the seven main Egyptian airfields were still functioning, another was only partially out of service and a fifth was reusable after only the repair of a few craters.[35] Despite light resistance and very well known targets, Bomber Command's performance was not impressive. The next year, at a bombing competition in the United States, Valiants and Vulcans gave another bad showing. Faulty electronics, operations at lower altitudes than the crews were accustomed to, and the relative unfamiliarity of the Vulcans contributed to the Valiants placing 27th and the Vulcans 44th out of 45 teams.[36] *Flight* magazine remarked, "Suez gave Valiant crews a taste of [working overseas], and the tropical atmosphere of Pinecastle has provided an even stiffer lesson. . . . The technical implications must now be taken to heart by [Bomber Command]. Much remains to be done before it becomes a wholly effective nuclear force."[37] While not necessarily reflecting on the quality of personnel, Suez and Pinecastle show the medium bomber force's general unpreparedness for any task in 1956 and 1957, let alone for the most daunting task at hand, a strategic nuclear campaign.

Problems with aircraft were not the only potential obstacle for the first generation British deterrent. An advanced bomber without weapons is little more than an expensive airliner. Until enough domestically produced atomic weapons were deployed, the R. A. F. would have had to rely on American bombs. This would have confronted Bomber Command with at least three problems. First, prior to Project "E" there were no formal arrangements for providing the R. A. F. with American bombs, which moreover, would have been illegal under the Atomic Energy Act. Secondly, the Lincolns and wartime Washingtons were probably incapable of carrying American atomic or nuclear weapons without time-consuming modifications. Thirdly, and perhaps most troublesome, the American atomic stockpile in the late 1940s was quite small—two bombs in 1945, nine in 1946, thirteen in 1947, fifty in 1948, and two-hundred-fifty in 1949.[38] It is difficult to believe that the U. S. would have handed over such a scarce resource even to the closest of allies when needed by American forces. The U. K.'s strength in atomic bombs expanded just as slowly during the mid-1950s. One estimate of the British stockpile puts its size at one weapon in 1953, four in 1954, ten in 1955, fourteen in 1956, twenty-two in 1957, and forty in 1958.[39] This might just have been adequate for the small number of bombers then in service, but it hardly constituted an overwhelming striking force. Even Project "E" did not completely solve this problem, since it conflicted with British operational procedures.

Bases posed another obstacle to Bomber Command's effectiveness. Prior to the introduction of the long range V-bombers, Bomber Command needed many bases to reach all of its targets in the Soviet Union. In 1948, the Chiefs of Staff estimated that by 1957 they (and the West more generally) could definitely count on bases in the U. K. and Alaska, perhaps Egypt and Japan, and possibly Pakistan or India. Even with all these bases, they estimated that large tracts of the Soviet Union would be inaccessible, including the northern half of the Urals, the Upper Volga basin, eastern Siberia, and Pechora. Without Pakistani bases, the entire Ural region, the Kuzbas, Karaganda, and all of central Asia would be unreachable, and yet strategically vital. Logically, the Chiefs of Staff feared that Soviet atomic energy plants would have been located far from existing American and British bases.[40] In reality, by 1957 the British had lost access to bases in Egypt. Even if using German or Pakistani bases, short-legged Lincolns and Washingtons would have been hard pressed to destroy anything but a peripheral target. This problem, however, declined after the introduction of longer-range V-bombers in the late 1950s while the R. A. F. also took measures to base them more flexibly. For example, in 1958 the U. K. modified its Singapore facility to support both V-bombers and their nuclear weapons.[41]

Intelligence was another—and perhaps the most critical— weakness in the British deterrent through the mid-1950s. While British military intelligence was excellent in quality and linked effectively with its counterparts in Washington[42] and other Western capitals, until the late 1950s knowledge of Soviet targets was severely limited. Even atomic weapons require accurate targeting to be fully effective, doubly so when stockpiles were limited. Although the West used many techniques to gather strategic intelligence on the Soviet Union, it took several years before they bore fruit. Thus one American program, Operation "Turban," used captured German wartime photography which, of course, did not extend beyond the formerly occupied portion of the European U. S. S. R.[43] Interrogation of German prisoners-of-war yielded some more information, but again, this was limited to installations the P. O. W.s observed and facts they could accurately recall.[44]

Naturally, Western intelligence operations were not limited to German sources. The U. S. and U. K. began to conduct missions around the Soviet periphery as early as December 1947.[45] Intensive electronic intelligence collection and "slant" photography (i. e. pictures taken at an angle from international airspace) provided information about peripheral Soviet installations, but very little about targets in the interior.[46] To acquire the necessary information, the U. S. and U. K. began deep and potentially dangerous overflights of Soviet territory. An unmanned project using balloons, Operation

"Genetrix," lasted four months from December 1955 to March 1956. Despite producing nearly 14,000 visible exposures, the project's only major achievement was to locate a previously unknown nuclear refining facility in Siberia.[47]

Manned overflights eventually provided the necessary information. Early American attempts using late-1940s aircraft were numerous, hazardous, and provocative. In 1950, Air Force General Nathan Twining boasted that, "one day, I had 47 airplanes flying all over Russia."[48] At the Central Intelligence Agency's request in 1953, the R. A. F. flew a modified Canberra from a base in West Germany across the western half of the U. S. S. R. over the Kapustin Yar missile testing site. When the plane landed in Iran with serious damage, London refused to repeat the exercise.[49] The true breakthrough came with the American U-2 program. The specially built reconnaissance aircraft first flew over the U. S. S. R. on 4 July 1956. The C. I. A. believed that the aircraft's operational altitude of around 70,000 feet was higher than any Soviet defenses could reach.[50] As Francis Gary Powers would discover four years later, the C. I. A.'s estimate was in error. Nonetheless, the program finally gave the West the targeting information needed to guide an effective atomic war. It located previously unknown trans-Ural cities, military installations, and, most importantly, atomic energy sites. When a C. I. A. official asked a senior officer in SAC's targeting section, "What has been the impact on your work of the U-2 project?," the officer replied, "As far as Russia and Siberia are concerned, we've had to start over from scratch." The target list grew from 3,000 to 20,000 as a result of the

U-2 program.[51] Simultaneously with the U-2 program, military overflights continued unabated and supplemented SAC's data.[52]

Even if the SAC officer was exaggerating, the very success of the U-2 demonstrates the weakness in SAC and BC planning through the mid-1950s. Not until the late 1950s did the V-bombers have the information needed to find and accurately attack their targets. The R. A. F. always recognized this weakness. In a lecture of July 1948, the future Chief of the Air Staff Sir John Slessor identified intelligence and targeting as serious handicaps to a successful allied air offensive.[53]

To reach those targets, Bomber Command's aircraft would have to penetrate Soviet defenses—never an easy task after 1945, and one which grew steadily more difficult. While the performance of Soviet air forces in World War II was mixed, the quality of its design staffs and the scale of its productive facilities was impressive. In more general terms, its weapons and military industrial capacity were imposing in both quality and quantity. After the end of the war, Stalin placed air defense near the top of the Soviet Union's military priorities.[54] From 1945 to 1960, Russian engineers made immense strides forward in jets, anti-aircraft guns, radar, and guided missile technology. Interim post-war jet fighters such as the Yak-15 and Mig-9 used captured German engines and ideas. Ironically, the Mig-15, so successful against the B-29 in Korea, was powered by a Soviet copy of a British engine.[55]

By 1949, Western intelligence credited the Soviets with 9,450 fighters, including 1,500 jets. While the PVO Strany (Air Defense Forces) did not directly control all of them, one joint estimate put that branch's strength at about 1,800 fighters. However, this figure was not very reliable because, "the detailed location of these aircraft is not assessed owing to lack of information."[56] Soviet strength in jets continued to climb through the 1950s. By 1952, Soviet industry produced 15,000 Mig-15s alone (some of which were exported).[57] Four years later, U. S. intelligence estimated that the U. S. S. R. had 10,500 jet fighters, 3,850 in the PVO.[58]

Steadily increasing quantity was matched by ever greater quality. A typical mid-1940s Soviet piston interceptor, the La-9, was armed with four 23mm cannons, could reach 32,000 feet, and had a maximum speed of 375 miles per hour.[59] Lincolns and Washingtons would probably have performed effectively against defenses composed mainly of this kind of aircraft, but not against their successors. A representative early jet fighter, the Mig-9, carried two 23mm cannons and had an estimated ceiling of 44,000 feet and top speed of 515 miles per hour.[60] The Korean War era Mig-15 could reach 50,500 feet at 520 miles per hour.[61] By the mid-1950s, as the very first V-bombers rolled off the production line, newer Soviet fighters appeared. The Mig-17 had a combat ceiling of 58,900 feet and could fly at 650 miles per hour. The Mig-19 flew slightly lower, at 58,200 feet, but at speeds approaching 700 miles per hour.[62] Either aircraft was easily capable of intercepting and destroying the V-bombers not even yet in service.

Through the late 1940s and 1950s, not only fighters but Soviet air defenses grew more sophisticated. Using German technology, the Soviets fashioned a skeleton early-warning system in the Baltic and Eastern Europe. By 1950, this system extended to the

Pacific Ocean and the Caspian and Black Seas. By 1952, as painfully discovered by American forces in Korea, the Soviets built and maintained a network of twenty-five early warning stations and eleven ground controlled intercept* stations at Antung in Manchuria. This system could place Migs within two to five miles of a target at distances up to seventy miles away from the station.[63] A 1956 estimate stated, "while areas along the northern and southern borders may have some radar gaps, it is believed that significant numbers of early warning radars will be found on approaches to the most important areas in the USSR."[64] Thus, the Soviets would have been able to track most bombers entering their airspace and had already demonstrated the ability to perform effective and massive ground controlled interception in small and well defended areas the size of North Korea. This would have supported an air defense system combining widespread early warning with a competent command and control system for regional and point air defenses (but not continental).

That the Soviet air defense system was far from perfect at intercepting aircraft flying at the altitudes preferred by the V-bombers is obvious. After all, hundreds of Western aircraft intruded on the peripheries of Soviet airspace in the 1950s. A Canberra in 1953 and scores of U-2s between 1956 and 1960 passed across the entire U. S. S. R., while two South Korean airliners accidentally overflew hundreds of miles of the most sensitive areas of the Soviet Union in 1978 and 1982. Yet this C^3I system was good and it rose steady in quality, until by 1960 U-2 flights over the U. S. S. R. became suicidal. By

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* Ground controlled intercept (GCI) - a fighter is directed to the target by instructions from a radar operator.

1963, the R. A. F. concluded that this system was so effective that the V-bombers must abandon the entire approach of high altitude bombing for which they had been intended and seek to evade the system through low level approaches.

During this period the Soviets also developed other novel technological threats to a strategic bombing campaign. The first Soviet air-to-air missile, the AA-1, appeared in the mid-1950s for use on the Mig-17 and Mig-19.[65] A few years later, the first surface-to-air missiles were deployed around Moscow.[66] Both quantitatively and qualitatively, Bomber Command faced an increasingly difficult task. The first generation of V-bombers had been designed to a 1947 specification, based primarily on experience against German air defense systems of 1943-44. The standard of air defense was far greater by the time the V-bombers finally reached service in the late 1950s. Whether the V-bombers could have met the standards required for success in strategic air warfare of that period is open to question.

At the end of the 1950s, the V-force consisted of from 70 to 100 aircraft, reaching its largest numerical strength in June 1964—50 Valiants, 70 Vulcans, and 39 Victors; 159 in all, between 33% and 66% of the strength which the Air Ministry had estimated in 1952 would be required for an effective counter-force campaign.[67] These numbers were not large and to make matters worse, not every one of these bombers would have participated in a campaign had war occurred. A few aircraft might have been grounded by maintenance problems and others destroyed at their bases, depending on the amount of strategic warning. Still more aircraft might not have been available for strategic operations if some were engaged in a conventional campaign during a mounting crisis. Those bombers that did get off the ground would fly toward any weaknesses in the Soviet early warning net. A combination of electronic jamming and strikes against specific air defense installations would probably have created or widened gaps for the deeper strikes. Nonetheless, as the bombers approached their targets many would have been picked up on radar. The Soviet air defense system was not an omnipotent force throughout its whole domain. It had weaknesses which the V-force (not to mention SAC) would have exploited to the fullest. Nonetheless, it presented a formidable quantitative and qualitative challenge by the late 1950s. In 1954, the PVO switched from a primary focus on point defense, where a few important targets (e. g. Moscow) would be defended by successive waves of fighters, to regional air defense.[68] Thus, a strike in 1958 would have faced defenses in each region it passed over, but that opposition would have been lighter in remote areas with fewer potential targets. Those aircraft which passed this gauntlet and found their target, avoiding any potential problems with weather, inaccurate maps, or malfunctioning equipment, would have then faced thick defenses. The more important the target, the stronger its defenses. The more important points in the late 1950s were guarded by batteries of surface-to-air missiles in addition to anti-aircraft guns. Whether or not the bomb fell on target and exploded properly, the aircraft would have to fly out of Soviet airspace through probably fewer but certainly more vengeful defenses.

Assessment of the success of a Bomber Command offensive through the late 1950s involves a study of four permutations. The first is an independent campaign using only wartime equipment, Lincolns and Washingtons. The second is a joint Anglo-American offensive in the late 1940s using the same obsolescent aircraft. The third is an independent campaign with the first generation V-bombers. The fourth combination is an Anglo-American campaign using the V-bombers together with SAC's B-47s and B-52s.

The first kind of offensive faced insurmountable obstacles. Obsolescent bombers, the lack of atomic bombs, insufficient bases, poor intelligence, and ever stronger Soviet air defenses meant that until 1956 Bomber Command was incapable of an independent strategic air offensive. In an autonomous campaign, Lincolns and Washingtons, even if they had used vulnerable bases in Germany, could not have reached targets beyond the Western U. S. S. R. Armed with conventional weapons, they would have had little impact on the Soviet Union. Had they somehow managed to secure American atomic weapons, the bombers would have had to penetrate strong and imperfectly known Soviet air defenses in order to reach targets whose location was sketchy at best.

These factors would have plagued a joint offensive as much as an independent British one, with one major exception. Strategic Air Command's larger inventory and widespread bases would have partially mitigated the effectiveness of a Soviet defense. Even so, Western success in strategic air warfare was not certain. An American study undertaken in 1949 probed the outcome of a strategic air offensive against the U. S. S. R. carried out with contemporary equipment. This paper's lessons about American strikes can be equally applied to a single handed British attack or a coordinated Allied campaign. The report assumed poor intelligence about the simulated target area around the Black

Sea and its defenses. It compared two levels of Soviet defence, one with technology of 1945 and another with more modern equipment incorporating Luftwaffe materiel, against two different U. S. forces operating at both day and night. The larger daylight offensive pitted 260 B-29s and B-50s together with 20 B-36s and 72 long-range reconnaissance aircraft against a competent Soviet defense equipped with 270 jet fighters and 550 piston fighters. Here the U. S. raid suffered horrific losses. In 1221 sorties, the simulated offensive delivered 153 bombs on target, at the cost of 222 aircraft lost and 27 damaged —a 55% casualty rate. Against a night defense, the same force delivered 176 bombs on target at a cost of 123 aircraft destroyed and 25 damaged—32% casualties. Either rate of losses would have wrecked the campaign. Other crucial obstacles to the success of the operation included inadequate supplies of spare parts, ordnance, personnel, and transportation. The key weakness was scant strategic fuel reserves, which the study estimated at only enough for 2,000 sorties. The report concluded that SAC probably could not carry out its currently planned offensive.[69] The less technologically advanced Lincolns would undoubtedly have suffered higher casualties. Furthermore, since the simulation envisioned that U. S. aircraft would have only thirty-two atomic bombs, it is unlikely that any of them would have been placed on the more vulnerable British aircraft. Thus, between the late 1940s and the late 1950s, the value of Bomber Command even in a joint strategic campaign was close to nil.

The third permutation of Bomber Command offensives, an independent campaign with the V-bombers at, for instance, the end of 1958 would have fared better. Some

British bombs were available, and there were arrangements for obtaining American weapons. The bombers flew much faster and higher than those they replaced. Several years of training and re-equipment had minimized chances of another Suez or Pinecastle debacle. The problem of basing was less significant for the longer ranged V-bombers, while knowledge of Soviet targets was beginning to become effective. Despite this progress, Soviet air defenses were very strong. An attack by the seventy-three operational medium bombers would undoubtedly have taken heavy casualties. However, some V-bombers probably would have penetrated to and destroyed their targets. The obvious question is what number of bombers would have done so.

One analysis, by former R. A. F. pilot Andrew Brookes, states that the V-bombers —his case is for the second generation in 1962—would have been able to penetrate Soviet airspace in significant numbers. His principal evidence is the performance of the Soviet-built North Vietnamese air defense system around Hanoi during the Linebacker II campaign of 1972. Brookes argues that the B-52Ds used in those attacks were even less capable than the first marks of V-bombers, yet they accomplished their mission. Moreover, the North Vietnamese defenders had the advantage of knowing that the Stratofortresses would be hitting the same targets every day, and coming from the same bases. He cites the two percent loss rate suffered by the bombers during the campaign and concludes, "there was no reason why the V-force ten years earlier should have suffered appreciably higher losses than the B-52s in Linebacker II."[70] If so, then some seventy-five

V-bombers might well have been able to penetrate Soviet air defenses in search of their target—providing real warfighting capability by any standard.

There are, however, several problems with this analysis. First, the U. S. A. F. had total air superiority over North Vietnam by 1972. No Migs even rose to engage the lumbering B-52s. By comparison, the V-force would have faced swarms of the most advanced Soviet fighters flown by the East Bloc's best pilots, and at this time, interception by a fighter most likely meant the destruction of a bomber. Secondly, the B-52s countered late 1950s and early 1960s vintage SA-2 surface-to-air missiles with the best electronic counter measures available in 1972. The V-force would not have had such advanced technology to depend on—indeed the technical balance would have favored the defender. The missile systems would not have been well known to an attacking British force in 1958 (or even 1962), while SAC's aircraft could call upon both its own experience since 1965 and Israel's in 1967. Thirdly, after seven years of war SAC knew every inch of North Vietnam and its air defenses and knew exactly how to reach its target. In 1958, Bomber Command would not have had nearly that level of intelligence on either its targets or their defenses, and many of its aircraft might never have found a worthwhile target, let alone those they were assigned.

Despite the weaknesses in his arguments, Brookes does make an important point. Air defense systems historically tend to be overrated. A coordinated strike by expert crews in technologically sound aircraft—the 1958 V-force—would likely have reached a number of targets. However, they would not have enjoyed the freedom of the U. S. A. F.'s B-52 in 1972.

Whether in case of war this level of destruction would have been enough to stop a Soviet invasion of Europe is a matter open to speculation. Although British staffs no doubt assessed this issue in detail, those documents are still closed to historical study. However, in 1955 an American study came to several negative conclusions about the effectiveness of a strategic campaign waged with equipment comparable in quality and vastly superior in quantity to the V-force. It holds lessons for both the independent and joint campaigns with jet bombers. Under the worst case—an entirely plausible case—Soviet atomic capacity would be free for use against its designated Western targets, and many Western bombers would have been destroyed on the ground or in the air over the Soviet Union. Still, the study began with the optimistic assumption that, "all allocated weapons reach the designated bomb release lines[†]." This study made several important points about a full scale strategic air offensive.[71] One principal conclusion was that unless the Soviet government collapsed or Western forces located then unknown stocks of war materiel, the Soviet Bloc "would not suffer supply limitations during the first four to eight months of the war."[72] Moreover, the "neutralization" offensive (i. e. destroying Soviet atomic delivery capacity—"Bravo" or "Blunting" targets in earlier parlance) was

> critically dependent upon delivery of the U.S. strike prior to Soviet atomic launchings. Even if the U.S. delivers the first atomic strike there is no assurance that the Soviets would be prevented from lifting a significant number of atomic

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† Presumably, the study's authors meant that all the bombers would reach the point where they would drop their bombs. However, this does not necessarily mean that all the bombs would actually be released or detonate (e. g. stuck doors, faulty warheads, etc.).

> weapons against either the U.S. *or its Allies* or both during the emergency period. [emphasis added][73]

Thus, even under the best circumstances, "there can be no assurance that this offensive would completely neutralize the Soviet atomic capabilities."[74] The study went on to say that aircraft losses could not be accurately estimated because the authors did not know how effectively the Soviets could use their "relatively long early warning times available" in deeper strikes.[75] As for halting a Soviet invasion of Western Europe, the study stated, "if the Soviets concentrate their entire ground offensive effort in Central Europe . . . the Allies appear to have inadequate ground forces for a successful defense regardless of the number of atomic weapons used in their support."[76]

If this study has any accuracy, then the conclusion is stark and clear. If a full-scale offensive by the Strategic Air Command would not have prevented nuclear strikes on the U. S. or its allies nor the take-over of Europe in 1955, then the V-force acting alone would have had even less chance. Indeed, the independent British atomic arsenal had little warfighting capacity. Only if every V-bomber reached its target could the V-force meet the vital needs which the Chiefs of Staff had defined in the late 1940s and early 1950s. If one assumes the opposite extreme, that Soviet air defenses could destroy 90% of incoming aircraft, then in 1958 130 U. S. atomic bombs would have reached their targets, compared to just 8 British. On its own, the V-force could not destroy many—if any—Soviet counter-force targets. Hence it could not have reduced in the least the strength of an atomic attack against Great Britain, nor weakened the power of a Soviet blow into Western Europe or the Middle East. Nor could it have destroyed many Soviet cities or economic resources. Thus, the V-bomber program had not met one of the basic requirements which it had been intended to do—by 1957 it had not given the British the military capacity to reduce the damage the U. S. S. R. could inflict in an atomic war, or to allow Whitehall to run the risk of a single-handed conflict with the U. S. S. R.

On the other hand, of course, by 1957 the prospect of such a single-handed war was low, virtually impossible. Diplomatic decisions in Washington and Europe had solved half of the strategic problem feared by the Chiefs of Staff—that regarding its friends—while British influence over American atomic targeting to some degree allowed Whitehall to borrow American power so as to reduce the enemy's threats to Britain. As the Defence Committee noted in 1957, "we should never in practice expect to challenge the Soviet Union alone . . . . We could, therefore assume that we should not use strategic nuclear weapons except in alliance with the United States."[77] Prime Minister Macmillan wrote three years later, "Our purpose should be to maintain a strategic nuclear force which is accepted by the Americans . . . as a significant contribution to the Western deterrent. Without this, our standing in the Alliance would suffer and we should lose a valuable means of influencing American policy . . . ."[78] All this, in turn, helps to explain some of the fundamental characteristics in British diplomacy and strategy, the continuous striving for close collaboration with the United States and influence over the Pentagon's nuclear targeting, the way that successive Governments' strategic thinking was inextricably bound up in the special relationship. As Lawrence Freedman writes, "the standing alone hypothesis has never apparently taken precedence over private rationales advanced for Britain's nuclear force in the objective of enhancing Anglo-American cooperation."[79]

When not trying to attack 2021 targets on its own, but instead acting as part of a larger allied force including, at the end of 1958, 380 B-52s and 1,367 B-47s, even 73 V-bombers had much to contribute.[80] Certainly, the U. S. A. F. did not view the medium bomber force as a useless duplication of its own capability, but saw it as a valuable supplement.[81] Indeed, the V-force had a major advantage over Strategic Air Command forces based in North America—its proximity to the Soviet Union. Because they were six hours closer to their targets than SAC aircraft flying over the North Pole, British bombers would have formed a significant part of the first wave to strike Soviet defenses.[82] Moreover, the crews of the V-force were the best in the R. A. F. Personnel all needed "above average" ratings to enter the force. The pilot required 1,750 hours as first pilot; the co-pilot needed 700 hours as captain. The navigators even needed a tour in Canberras before they were eligible to join the V-force.[83] In short, as Slessor boasted, the V-bombers and their crews in the late 1950s, were, "as good as any in the world."[84] For several years after 1957, geographic advantage, technical parity with current American aircraft, and high quality crews would have allowed the V-force to play an important part in a combined offensive. Bomber Command's value was the highest under the fourth and final offensive permutation.

However, continued advances in Soviet capabilities eroded the value of the first generation V-force. The quality of Soviet fighters, surface-to-air missiles, and radar systems advanced quickly while the advent of medium and intermediate range ballistic missiles threatened not only to perform the V-bomber's work more effectively but also to destroy it. Soviet missiles based in East Germany could reach British air bases in four minutes.[85] The R. A. F. tried several different methods to overcome the limitations to the first-generation V-bombers. Larger engines, and in the Vulcan's case a modified wing, allowed "Mark 2" Vulcans and Victors to climb higher and fly faster—further away from Soviet fighters and missiles. Improved electronic countermeasures and other defense suppression devices strengthened the upgraded aircraft against enemy radar and missiles. The advent of a stand-off bomb, Blue Steel, let medium bombers launch weapons further away from enemy defenses, while the introduction of the H-bomb into service greatly strengthened the striking power of the V-bombers. In 1963, when the futility of flying ever faster and higher became apparent, the R. A. F. adopted a low-altitude attack profile to fly under Soviet defenses. To deal with the IRBM threat, Bomber Command instituted "Quick Reaction Alert" which allowed them to get off the ground in roughly two minutes.[86] The second generation of V-bombers carrying standoff megaton weapons was a far cry from the first generation of bombers carrying freefall kiloton bombs. Yet, these measures were only stopgaps. They merely slowed the rate at which the warfighting capability of the V-force eroded. They could not prevent the erosion, nor could Britain through its own unaided resources find an effective replacement for it.

This period marked an important moment in British history as a Great Power. Whatever its problems, the V-bomber force was still competitive unit for unit with its U.

S. and Soviet counterparts. By the later 1950s, however, the advent of the H-bomb, new air defense systems, ICBMs, and SLBMs created the second generation of the nuclear age. These obstacles reduced the effect of aircraft like the V-bombers and the B-47. Britain could not come to terms with this new era. The U. S. could deploy large numbers of B-52s, SLBMs, and ICBMs—i. e. surmount the obstacles—and the U. S. S. R. do the same by the middle 1960s. Great Britain, however, could not—even though it was allocating much more of its GNP to military purposes than did other Western European states, or than it had done in peacetime between 1815 and 1939. Britain through its resources alone finally could no longer even compete in the central forum of military strength which made a power great. Cancellation of more advanced bomber and missile weapons systems caused Britain's deterrent to pass to the Royal Navy in 1969, and that power rested on technology borrowed from the U. S. that Britain could not itself create. Against this, of course, Britain did have practical control over these SLBMs and it was given all of this material because of the impact which the first generation British program had on U. S. decision making.

The atomic deterrent, the fruit of the program of the 1940s, yielded mixed results. Politically, it achieved its goals. The 1954 amendments to the Atomic Energy Act set the stage for future closer cooperation which was eventually realized with the 1958 Act. The early program also gained desperately sought influence over American nuclear targeting. Although it was not fully realized until after the successful hydrogen bomb test, scientific and technological exchanges with the United States restarted after Monte Bello.

The first generation deterrent was less successful from a military standpoint. The long delays in deploying the weapons systems shortened their operational lifetime. Until the V-bombers were available in 1955, Bomber Command had no strategic value in either an independent or joint role. It was reduced to little more than a nighttime tactical bombing force.[87] The 1952 Global Strategy Paper admitted, "at present the Atomic Air Offensive rests entirely in American hands," and it was right.[88] The new atomically armed V-bombers, once deployed in significant numbers in the last years of the 1950s, might have posed some threat to the Soviets independently, and would have been valuable in a joint offensive. Increasingly sophisticated Soviet defenses, however, entirely nullified the first generation deterrent around 1964, as evidenced by the decision to switch to low-level penetration with more capable aircraft. These aircraft and weapons were replaced by upgraded marks in the early 1960s, but still their deterrent effect eroded and was lost at the end of that decade. Although the upgraded Vulcans and Victors soldiered on into the 1980s, their hour had past. For a time in the late 1950s though, the fruits of this early program gave Bomber Command the strength to carry out its watchwords— Strike Hard, Strike Sure—and temporarily extended Britain's lease as a power to be reckoned with.

Notes

[1] Hansard Parliamentary Debates, 23 October 1952, col. 1277; John Baylis, Anglo-American Defence Relations 1939-1980 (New York: St. Martin's, 1981), 53.

[2] A. J. R. Groom, British Thinking About Nuclear Weapons (London: Frances Pinter, 1974), 156.

[3] Memorandum from Edmund A. Gullion to Paul H. Nitze, 4 March 1953, in Foreign Relations of the United States 1952-1954, vol. 2, part 2, ed. William Slany, et. al. (Washington: GPO, 1984), 1116.

[4] Memorandum of Discussion at 251st Meeting of the National Security Council, FRUS 55-57, vol. 20, ed. John Glennon et. al. (Washington: GPO, 1990), 115.

[5] "Statement of Policy by the National Security Council on Disclosure of Atomic Information to Allied Countries," NSC 151/2, 4 December 1953, in FRUS 52-4, 1257.

[6] Ibid., 1258-9.

[7] Groom, 160.

[8] Margaret Gowing, "Britain, America and the Bomb," in British Foreign Policy, 1945-56, ed. Michael Dockrill and John W. Young (London: Macmillan, 1989), 45.

[9] Groom, 156-60.

[10] Ibid., 160-1.

[11] John Baylis, Anglo-American Defence Relations 1939-1980 (New York: St. Martin's, 1981), 54.

[12] C. J. Bartlett, The Long Retreat: A Short History of British Defence Policy, 1945-1970 (London: Macmillan, 1972), 153.

[13] Ibid., 152.

[14] Baylis, 50.

[15] Humphrey Wynn, The RAF in the Postwar Years: The Bomber Role 1945-1970 (London: Ministry of Defence, Air Historical Branch, 1984), 254.

[16] Ibid., 255.

[17] Ibid., 261.

[18] Ibid., 274.

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Conclusion

The development of the first generation British atomic deterrent cost substantial time, money, and effort. This thesis has examined why it was developed, how (and how well) it was built, and has also compared its effect against the initial intentions from which it sprang. These issues were central to the United Kingdom's political and military standing as a power at the end of the 1950s. The atomic deterrent was Britain's first home grown strategic weapons system and its last. The independent deterrent was a technical and political triumph, but ironically it led to greater dependence on the United States, and this dependence in turn gave Britain far more military power than it had been able to create through its own resources. However, Britain's entire experience with atomic weapons was filled with irony. The atomic deterrent was a military failure which, nonetheless, succeeded in achieving initially unintended political aims and so allowed Britain to acquire American made weapons and thus to become a notable military power in the nuclear age.

Despite the novelty of the technology, the purpose of the early atomic program was rooted in Britain's past. Deterrence had long been central to the British strategic repertoire. Atomic deterrence, of course, was not identical to conventional deterrence, because of the nature of early atomic weapons. Prewar deterrence had been more precise and limited in its aim; the intention had been to deter an individual nation from taking a specific action. Where 15 inch guns at Singapore were intended to prevent a Japanese sea invasion of the base, the atomic deterrent was meant to prevent Soviet leaders from threatening any of London's vital interests worldwide. The United States was as important a "target" of the atomic deterrent as the U. S. S. R. British leaders realized that the security of the West, and of itself, depended on Washington's actions. They decided that Britain needed an atomic deterrent to be respected as an important power, to exercise the influence they wanted on American employment of the bomb, and to ensure that American warplans accounted for British strategic needs in the event of a full-scale atomic war.

These issues of deterrence were seen as vital to Britain's position as a power and so were Britain's needs in case of an actual atomic war. Unlike the superpowers, Britain was utterly vulnerable to atomic attack. The impossibility of stopping every Soviet bomber with a conventional defense combined with the Home Island's dense population and the destructive power of atomic weapons, caused a rethinking both of British military strategy and of the U. K.'s air defense. Military and political leaders decided to rely on destroying Soviet atomic capability at its source through nuclear counter-force targeting. If war came and this approach failed, the U. K. would be destroyed. London had no guarantee that the U. S. Air Force would destroy these targets for Britain. Therefore, Britain needed the capacity to do it itself.

The U. K. chose not merely to build a British bomb but to develop a way to carry the new deterrent to its target. In the late 1940s, the bomber was the only reliable means to provide this service. Moreover, atomic weapons fit well into R. A. F. doctrine regarding strategic bombing. Thus, for both political and military reasons Britain decided to develop an atomic deterrent carried by Bomber Command.

The first step in developing the deterrent was to build the weapon, and Britain was forced to do so by itself. Repeated attempts to restore atomic ties with Washington failed completely. However much London felt entitled to receive any substantial information about atomic weapons, including the methods for manufacturing them, this was denied by American domestic politics, desire for international control, and a pervasive desire for monopoly. As if lack of American cooperation were not enough, the early atomic program also had to overcome a faltering economy and competing demands for finance, raw materials, industry, construction, housing, and skilled manpower. The atomic bomb program may have been at the top of the Government's defense priorities, but defense often itself was *de facto* subordinate to other demands.

Considering these obstacles, it is amazing that the program succeeded at all. Two factors aided that success. First, British involvement in the "Manhattan Project" gave the project an important head start. The scientists already knew the principles behind the bomb design and knew that it worked. What they had to discover—or, more properly, to rediscover—were the manufacturing techniques. The second advantage was experienced and driving leadership. Under Christopher Hinton, the building organization at Risley constructed a small industry on time and under budget. Similarly, the bomb project under Dr. William Penney overcame technical and theoretical problems both minor and profound, and eventually produced an atomic bomb for a small fraction of the cost of the

American one. The success demonstrated British scientific, technical, and potential military prowess.

The delivery device, the V-bombers, was developed in a less efficient fashion, even though it rested on an industrial sector and on technologies in which Britain held a leading position. Admittedly, postwar aircraft posed great technological challenges. Jet engines, swept-back wings, and transonic flight confronted British aircraft designers. This task was made all the more difficult by the extremely advanced specifications issued by the R. A. F. in 1947. It called for an aircraft far more capable than any which Britain's aviation industry—or that of any country — had ever produced. In order to fly faster, farther, and higher, engineers had to push the limits of their knowledge and of the art simultaneously in several fields. As the V-bombers took shape, advances in one field often forced a costly and time consuming redesign of other components. Nor, with the project divided among several small firms, were the programs well managed or Britain's strategic resources utilized in the optimum fashion. These problems, combined with the relatively low priority assigned to the V-bombers in a weak economy, did not prevent the construction of technically good bombers but it did stop their timely deployment. Ironically, the atom bomb project, run on a shoestring and drawing on technological and scientific resources in which Britain was not strong, proved far more successful than the V-bomber project, which drew from industrial and design sectors in which Britain was powerful. It was here —in the sphere of delivery systems—that occurred the true failure of the British atomic deterrent.

By the mid-1950s, Britain had the bomb and the aircraft needed to form an operational deterrent. In purely technical terms, the project was a remarkable success. In 1958 Britain had the ability to deliver a substantial number of atomic bombs over a great range, a capability not far short of that possessed by the contemporary U. S. S. R. Until the mid-1960s it remained one of only three atomic powers and none of the other states which achieved that status during that decade—France, Israel, and China—did so at the scale which Britain had done or through their own unaided resources.

The effect of this first generation British deterrent, however, was mixed. It was a great victory at the political level. The project acted as a catalyst in the revival of Anglo-American atomic cooperation. Following Operation Hurricane, changes to the Atomic Energy Act allowed wider and deeper exchanges of information and technology, while negotiations began on military cooperation in the all important fields of joint targeting and weapons sharing. Full collaboration would have to wait for the successful 1957 hydrogen bomb test and ensuing alterations of the Atomic Energy Act in 1958, but the success with the atomic bomb began the process that would lead to that closer relationship.

All this investment in the 1950s paid major dividends throughout the remainder of the century. It gave Britain privileged access to American nuclear technology and research, thus easing the design and construction of new weapons. Above all it provided the ability to acquire off the shelf American delivery systems which Britain could not have developed on its own. All of this also furthered other British strategic and diplomatic aims. The development of Britain's first generation deterrent was the capstone of an effort to raise British credibility in Washington and to manage relations with the U. S. The British deterrent achieved these purposes.

Yet the military value of the first generation atomic deterrent was marginal. Until 1958, Bomber Command's combat capability was diminished by too few bombs to put on the aircraft, shrinking numbers of overseas bases, poor intelligence about potential Soviet targets, ever increasing Soviet air defenses, and the inadequate performance of early Lincolns and Washingtons. The deployment of small numbers of V-bombers at the end of the 1950s altered the situation. These more capable aircraft, combined with better intelligence and more plentiful bombs temporarily boosted the R. A. F.'s strategic value. While too few in number to be a significant independent threat, and thus to meet the counter-force strategy which was needed to ensure British survival in case of war, they would have been a valuable supplement to a joint attack. Within a few years, however, despite numerous stopgap measures, continued advances in Soviet air defenses had eroded the V-bombers' value. When the futility of these efforts became clear during the 1960s, Britain transferred Bomber Command's deterrent mission to the Royal Navy—from a home grown delivery system to a borrowed one.

All this begs the question: was the first generation British atomic deterrent credible? The answer to this ultimately hinges on Soviet perceptions of the V-force. Though there is not enough evidence to provide a conclusive answer, several factors must be considered when examining this issue. The Soviets had already demonstrated their ability to accept massive casualties in the pursuit of their goals during World War II. An independent British strike in 1958 with a handful of kiloton weapons would certainly have caused heavy casualties, but probably on a similar or even smaller scale than suffered during the Great Patriotic War. Possibly Soviet leaders might have discovered aims which would have made such a level of losses acceptable. This issue is rendered almost academic however, by the context in which the Soviets might have seen the British deterrent. An atomic strike against Britain would have also destroyed American aircraft and personnel based on the island, probably triggering retaliation by American forces. If that is true, then the deterrent impact of the British bomber force may have been negligible in Soviet eyes, because it could not realistically be divided from the larger joint force. This in turn complicates calculation of the deterrent credibility of the V-force. Deterrence-by-denial was impossible and although solid evidence is necessarily lacking, there is no reason to believe that British deterrence-by-punishment was a credible threat.

The first generation British nuclear deterrent marked a crucial moment in Britain's position as a power. In the fifteen years after 1945, Britain devoted as substantial a share of these resources to defense purposes as any other Western country. Developing a kiloton-yield fission weapon and the bombers to deliver it stretched British technological resources to their limits. It could not expect to solve its problems by applying more resources to them, only by using them more effectively. Here, very clearly the British were trying to do too much and not succeeding in doing enough—proof that they could not any longer match the U. S. and the U. S. S. R. or remain in the first rank of Great Powers. The U. S. and U. S. S. R. could face major problems in weapons programs and yet recover from them—the conditions which eroded the value of the V-bombers did precisely the same to the B-47s, yet the U. S. responded with better aircraft in larger numbers and also with ballistic missiles based on both land and sea. The Cuban missile crisis demonstrated the utter strategic bankruptcy of the U. S. S. R., yet within five years it had deployed the ability to destroy much of the American population. Britain could not overcome such obstacles.

In purely technological terms, Britain might well have been able to acquire the next generation of ballistic missiles armed with megaton weapons through its efforts alone, but this could not be done in a reasonable amount of time, nor at a price which Britain was willing to pay. This failure in the nuclear age was shaped by the nature of Britain's success in the atomic era. The opportunity cost involved in the development of the atomic deterrent hampered its ability to create a fundamental part of the nuclear deterrent—the delivery system. In particular, Britain was thrown off balance by the fact that the only plausible delivery system in 1945 became a marginal one against the U. S. S. R. twenty years later, while delivery systems—ballistic and cruise missiles—at a primitive state of evolution and requiring long and costly development with no guarantee of success, proved to be the most useful ones. Whereas all British expenditures on atomic weapons between 1945 and 1954 laid a foundation which could be used to support further developments in nuclear weapons, investment in V-bombers could not assist further developments in nuclear submarines or missiles. Rather, the opposite—the V-bomber project reduced the size of the research and material procurement budgets which might otherwise have gone to these projects. The time, money, and effort put into producing three kinds of V-bombers also tied up much of Britain's design potential in a single specification, hampering the ability to design the next generation of bomber which might have been better suited to delivering the bomb. Moreover, the cost in finance and in the scientific and engineering manpower tasked to develop the V-bombers and the atom bomb hampered other crucial conventional defense projects, including research into guided missiles—which proved central to delivery systems in the nuclear age. While pursuing its own atomic deterrent, Britain could not simultaneously stay at the forefront of research on guided missiles, ballistic missiles, advanced tanks, civil airliners, and a host of other postwar fields.

Success in the development of the atomic deterrent did not achieve the aim of keeping Britain a Great Power, yet neither was it a failed investment. Again, however, the gap between intention and effect was bridged by irony. The first generation deterrent was designed to foster a close relationship with Washington and Britain's status as an independent Great Power. Instead, it created dependence on U. S. weapons systems. The cancellation of the Blue Streak IRBM was followed by collaboration with the U. S. on the Skybolt stand-off missile. This weapon system was intended to extend the lifetime of the V-bomber, but the policy failed and Britain's very status of a power came into question when the Pentagon pulled out of the project. British leaders had debated seriously whether simply to let the effect of the V-force erode rather than incur the relatively limited expenditures needed to modify it; for the same reasons, they had kept the V-force at only

60% of the strength which defense authorities had said was needed to maintain a credible deterrent.[1] Now they faced the dilemma either of Whitehall subsidizing another and entirely new strategic weapon system or of having none at all. Without Skybolt, with no British ballistic missile in production, and with the only way to keep bombers a useful deterrent being to develop entirely new ones and maintain a bomber force several times larger than the maximum strength of the V-force, London had to turn fully to American systems to maintain any deterrent credibility. The deployment of Polaris armed submarines in 1969 gave the U. K. an operationally independent deterrent, but demonstrated that Britain had given up the capacity to manufacture vital parts of its own strategic weapons.

The combination of political success and military failure of the first generation deterrent undermined long-term British strategic independence, and that underscored Britain's declining status. In 1945, the U. K. was a Great Power. Politically and militarily London controlled one-quarter of the globe. By 1995, Great Britain remained an important power, but only a regional one and of the second class. One of the main factors governing Britain's place in that rank was the fact that London retained nuclear weapons —but they were American designs and rested on American delivery systems. If one accepts the argument that no Great Power can live on the "sufferance" of another, the traditional British definition of that concept, then the passing of Britain's only domestically developed deterrent marked the end of its status as a Great Power. Ironically, Britain had a greater military power in the nuclear age after it ceased its attempts to remain a Great Power in the traditional sense than it had done while pursuing that status.

The first generation deterrent moved in paradoxical ways for several reasons: to an unusual degree for a weapons system, it always had both political and military aims which were closely intertwined; and because a project conceived at the dawn both of the atomic era and of the Cold War came into service during the start of the nuclear age and at a time when the political structure of the Cold War had reached maturity. The goals of the deterrent in 1945 were to keep Britain an independent Great Power and to serve as an insurance policy for British security against the Soviet Union if the United States withdrew into isolationism. By the time Britain successfully tested a bomb and deployed it on the V-bombers, these goals had been transformed. By the mid-1950s, British leaders realized that remaining a Great Power was impossible because Britain lacked the economic resources to remain in the top tier of powers. Meanwhile, the other goals had been achieved through different means. An American withdrawal from world affairs was impossible. That, in turn, undermined the need for an independent British deterrent. The strength of the ties between the U. S. and U. K. ensured that Soviet aggression against one would draw in the other, and indeed no Great Powers mounted major or immediate challenges to vital British interests. Moreover, by the time the British deterrent was deployed, the atomic era was rapidly becoming the nuclear age, and circumstances in which atomic bombs could be imagined as being used as a rational tool of war were being replaced by conditions of mutually assured destruction. As Prime Minister Macmillan noted in 1958,

> It was for consideration whether the fundamental assumptions on which our present defence policy rested were still tenable, or whether a reappraisal of the situation should now be made. The decision to produce a nuclear deterrent independently of the United States had been taken at a time when the Americans had possessed an overwhelming superiority in that field over the Soviet Union. It had been taken partly on account of the influence and prestige which we should gain in our relations not only with the United States, but also within the Commonwealth and with other countries of Western Europe; a second reason had been the military value of having an independent deterrent. This policy had paid good dividends and had been fully justified by events, especially the development of our relationship with the Americans during recent months. The basic situation had recently changed, however, in that the Soviet Union was now a major nuclear Power and that the two strongest nations in the world would shortly reach a state of 'nuclear sufficiency,' in which each could destroy the other. In this situation it was for consideration whether we still needed to take into account the possibility of having to use the nuclear deterrent independently of the United States, or to bring pressure to bear on them when our interests were threatened.[2]

Thus, by the time the deterrent was deployed, it served two other goals: maintaining British prestige in a general sense, and influencing the strategic policy of the U. S. and to a lesser extent, other European states. While no number of atomic weapons could keep London a Great Power, its deterrent could still provide Britain with great influence.

Militarily, the British atomic deterrent was a failure. Until the late-1950s, all of Britain's efforts in that direction served solely to make it a target for Soviet attack on American air bases. Yet, it could not have retaliated or adequately defended itself through its own means. After the deployment of the V-bombers, Britain *still* could not have retaliated or defended itself effectively. Great Britain never had its own effective atomic warfighting capability and so remained more vulnerable that either the U. S. or U. S. S. R.

in case of war. The British deterrent was not an independent threat to Moscow, nor more than an (albeit material) increment in strength for Washington. Britain's true security lay in the American nuclear umbrella. Yet if ever that deterrent had failed, arguably Britain would have been among the countries most devastated by atomic war.

By the late 1950s, the effect of the British deterrent was unlike that planned in 1945. It did not keep the U. K. great or secure—but it did make the U. K. even more worthy of an alliance than it would have otherwise been. The most important achievement of the atomic deterrent lies in the influence it gave London over the larger American force and on American strategic calculations—especially the decision to let the British acquire the Polaris and Trident SSBN systems. In turn, this provided the solution to the paradox of military failure and the inadvertent success of initially unintended political aims which marked the British program. The U. S. gave the British the military technology needed to have a credible deterrent capability in the nuclear age, and it did so partly because of the access the British achieved in the 1950s. Naturally, the British had no intention in the 1940s of giving up the ability to produce their own strategic weapons systems. They wanted a closer political relationship with the United States and an important part of that was technology sharing. However, when they did lose the capability to keep up with emerging technology, that political relationship salvaged British strategic forces. As a result, the U. K. has had far more military success in the nuclear age than it had in the atomic age.

The unforeseen—but most important and most paradoxical—consequence of the early deterrent was the access it provided to and the later dependence it created on American technology, combined with complete control over these borrowed weapons. Had Britain wished to remain a truly independent nuclear power, it could not have developed modern weapons and delivery systems without a far larger investment than it has made. The opportunity cost of that venture would have set back Britain's other military scientific, and industrial ventures to an incalculable degree. The political achievement of the first generation deterrent made up for its military shortcomings, and eliminated the necessity either to abandon nuclear status or to pay heavily to maintain it.

Today, Britain remains in the second rank of powers. It is part of a select club of publicly declared nuclear states. The Anglo-American alliance, in which nuclear weapons play a central role, is still strong. Moreover, Britain retains a powerful deterrent in the form of Trident missiles. Without the first generation deterrent, none of that could be true today. Both Britain and the world have changed since the end of the Second World War. There is no Soviet Union, no British Empire, and no Bomber Command. But one thing which has not changed is that Britain still has permanent interests—and the tools to defend them. Even if some of the components are stamped "made in the U. S. A.", British fingers are on the buttons and there is a Union Jack on top of them.

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