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U. S. AIR FORCE
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IS THERE A DEFENSE? (U)

Bernard Brodie

RM-1781

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3 October 1956

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PREFACE

The following paper is intended as a chapter of a longer study on a general theory of air power in the atomic age. Another chapter has already been released as RM-1013, "The Heritage of Douhet," and others will be similarly released as rapidly as possible.

This chapter is not intended for specialists in the field of its subject matter. It does not concentrate upon one limited aspect of the air-defense problem with a view to recommending new kinds of hardware or operational techniques. It seeks, rather, to appraise the basic capabilities of air defense, now and in the future. The object is to discover the degree to which we can rely upon such capabilities in formulating our over-all military strategy, and indeed our national security policy.

The appraisal starts with an analysis of the adverse doctrinal background against which defense claims have to struggle for a share of the national military budget. It proceeds with an examination of the warning problem, and then of the prospects for worth-while defenses of both the active and passive kinds. Positive conclusions are avoided as not justified by the character of the analysis, but the discussion in general tends toward the following position: we must

establish certain critical priorities in defense with respect to the objects to be defended (SAC obviously being at the top of the list among the latter); the over-all investment in defense necessary to protect suitably even the most carefully selected objects will in the future take a greater proportion of the national defense budget than it has heretofore, especially for provision of the passive varieties of defense; but, finally, even the most generous imaginable expenditures on defense will still leave us in a situation where all our larger cities and much of our civilian population are inevitably at risk. The latter estimate naturally forces the conclusion that the security of the country must rest fundamentally on military and political capabilities such as are not normally included in the catalog of defense measures.

Most of the factual information and many of the ideas I have picked up from others, especially from among my RAND colleagues. The number of my debts has prevented me from making suitable acknowledgment in every case.

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The Doctrinal Context

Much of the historical discussion of strategic and tactical doctrine has revolved around the perennial question of offense versus defense: Which is at what particular times the most appropriate form of war? The discussion has not been free of an immense charge of emotion, which itself is often deliberately inculcated. Soldiers are not trained to be objective in questions of this sort. They are trained to be emotionally in favor of the offensive, just as ordinary persons are trained to be emotionally in favor of virtue -- and for much the same reason, which is that normal human impulses tend, or are suspected to tend, in the opposite direction.

Aggressiveness in a commander is considered a great merit, and military history suggests that it should be so viewed. The responsibilities of high command during wartime have often induced excessive caution in those who had it. The commander has always known that his decisions, besides having a direct effect on casualty rates, involved large risks and affected great political stakes. During battle he could see the hurt to his own forces (whose dangers he often shared), but could only guess at that to the enemy; he could see the weariness in his troops, and yet had to drive them to that superhuman exertion and resulting exhaustion that on a mass scale are peculiar to war. General Meade excused himself for his passivity

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at the close of Gettysburg partly on the ground that his men were tired. His observation was certainly correct, but his judgment was profoundly wrong. His already passive attitude had no doubt been confirmed by seeing his renowned adversary, General Lee, fail in several costly attacks culminating in the desperate waste of Pickett's charge.

Meade's behavior cost the Union dear. It is significant that it is his kind of error, and not Lee's, that has been kept alive for the military lessons to be derived from it. Pickett's charge has certainly not been forgotten; but if it is occasionally called a blunder, it is treated as an isolated and atypical one in the career of a very great general. It was, in short, an error in the right direction, and therefore not the stuff of which lessons are properly made.

That is no doubt a just evaluation. Our purpose here is not to condemn the doctrinal bias in favor of the offensive, but simply to note it. Although bias in the scholar is clearly a fault, the military commander practices a very different art. War has always entailed strains and agonies and dangers, and it would be absurd to assume that its chief actors could face up to it without the support of a doctrine which may to some degree offend against reason or sensibility. Ardant de Picq saw that fact clearly as a scholar, and as a soldier he confirmed it in

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the manner of his own death.¹ On the other hand, it would also be absurd to deny that this bias has been responsible for many disastrous blunders.²

Eagerness to attack and persistence in it despite strong resistance, which to the civilian often spells callousness or worse, may to the trained soldier signify adherence to the highest standards of professional conduct. There have been ups and downs in this tradition, and certainly the period just before and during World War I was one in which the offensive idea was pushed to grotesque extremes at the very moment that technological conditions gave it the least support. Nevertheless, beginning with Napoleon, there has not been a time when

¹ Col. Ardant du Picq, who was killed while leading his regiment near Metz in the early days of the Franco-Prussian War in 1870, wrote some highly original studies of the psychology of the soldier in combat. A complete edition of his writings was published in 1902 under the title of Etudes sur le Combat.

² Of the many examples that could be cited, an intriguing one is discovered in the writing of two Japanese naval air commanders present at the Battle of Midway, who attribute the Japanese disaster there to inadequate search resulting from overemphasis on preserving offensive strength. "Ten per cent of total strength was all they were willing to spare for search operations, feeling that the rest should be reserved for offensive use." (Mitsuo Fuchida and Masatake Okumiya, "Prelude to Midway," U.S. Naval Institute Proceedings, Vol. 81, No. 5, May 1955, p. 511; also p. 513. See also the same authors' book, Midway, The Battle That Doomed Japan: The Japanese Navy's Story, ed. by Clarke Kawakami and Roger Pineau, U.S. Naval Institute, Annapolis, 1955.)

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the doctrine of the offensive actually yielded its ascendancy in the scale of military values. Even in the era of the Maginot Line, French generals insisted that their over-all strategy was still offensive, although the ardor for the offensive of the previous generation of generals had undoubtedly been dimmed. No listing of the "principles of strategy" ever fails to include, at or near the top, one called the "principle of the offensive," which takes the form of an elegant restatement of the truism that "wars are not won by remaining on the defensive."

This bias for the offensive creates special problems in any technologically new situation for which there is little or no war experience to assist one in reaching a balanced judgment. For example, through the interwar period, and until nearly a full year after the United States entered World War II, the prevailing doctrine in the U.S. Navy concerning the amount of antiaircraft armament to put aboard combat ships was: "Don't sacrifice offensive for defensive armament!" In practice this slogan resulted in extremely lean allotments of antiaircraft guns on our major ships at the time of Pearl Harbor. Yet at the same time our battleships, old and new, were carrying armor amounting to 35-40 per cent of their unloaded weight -- the major part of it, incidentally, being vertical, above-water

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armor useful against gun projectiles but not against bombs or torpedoes. The value of the armor had been proved in naval engagements over the previous eighty years, but that of anti-aircraft guns had yet to be similarly demonstrated.

We must therefore be prepared, in considering the problems of strategic air defense in the atomic age, to find the military selling the defense somewhat short. We may in the end agree that they are in general right, but this general judgment does not provide the answers for particular problems, such as whether we ought to spend more or less than we are currently spending on defense, and on precisely what kinds of defenses we should spend our limited allotments.

The common attitude of disdain for defensive functions and machines tends to be an important factor in determining our own defensive capabilities. There are aspects of our defenses which could conceivably become very important but with which the military simply do not wish to become involved. That vast range of facilities, activities, and functions that might be grouped under "civil defense" are a case in point. The view that this field should be left to the civilians implicitly contains the argument that it should not get too much attention, i.e., money. Yet it is probable that many of the counter-offensive capabilities of the country following a thermonuclear

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attack, at any rate the kinds of capabilities the Army is concerned about, would depend among other things on the preservation of domestic order, which might require a considerable intervention by the Army.

So far as our most immediate retaliatory arm is concerned, there is no doubt that the Strategic Air Command is keenly concerned with its own security against enemy attacks. But that tells us nothing about the methods for achieving security for which that organization is likely to show a predilection, nor the price in offensive armament (within the context of an always-limited budget) that it is willing to pay for such security. In this realm of vital choices, it would be surprising indeed if one did not observe the bias described above operating in potent fashion.

In a previous paper we gave Douhet good marks for detaching himself from what he called "the mystique of the offensive." Perhaps "detachment" is not the right word, because he not only separated himself from that "mystique" but railed against it.³ We noted that his view that in ground war the defensive was vastly superior to the offensive was in fact proved by subse-

3 RAND Research Memorandum RM-1013, "The Heritage of Douhet," December 31, 1952.

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quent events to be wrong. But he was right when he insisted that in the air the situation is the exact opposite from what he presumed it to be on the ground, and that in the air the offense is not simply the stronger but the only valid form of war.

Why should the situation in the air be so different from that on the ground? Let us first consider ground war. We know that an army has always moved somewhat ponderously, limited in speed until very recently by the marching capability of the foot soldier, and that its movements are canalized by various features of geography, especially the highway and railroad system. In the remoter past swift mounted couriers, and for the past hundred years the telegraph, have served to bring the defender days and even weeks of warning of a descent upon his vital areas, usually with much information about the direction and schedule of the enemy's movement and the magnitude of his power. Important strategic surprise could be won by the attacker through deception or exceptional marching prowess, or through willful blindness on the part of the defender; but once a march began to proceed through hostile territory further achievement of surprise was likely to be limited and qualified. Moreover, since the attacker was normally descending upon the

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heart of a country from its periphery, the defender had the advantage of interior lines. This advantage made it relatively easy for the latter to redeploy to confront unexpected threats.

In 1914 the Germans were surprised at the speed of the Russian mobilization, which brought the Russian offensive into East Prussia at an earlier date than it had been expected; but once the Russian armies crossed the frontier their movements could be checked and clocked, and the arrangements for their decisive defeat at the Masurian Lakes could be thoroughly organized. Similarly, the French were surprised to learn that the German armies were pouring into Belgium earlier and in much greater strength than predicted, and that the direction of their movement was not in accord with French expectations. Nevertheless, following the collapse of their own ill-starred offensive in the east, the French were able entirely to redeploy their own and the British armies and to check decisively the descent from the north at the first Battle of the Marne.

Their failure similarly to contain the German penetration in the Ardennes in May, 1940 -- which also was a surprise in that the French expected the major weight of the German attack to fall elsewhere -- was due not to any fabulous speed of movement on the part of the invaders, the bulk of whom were after all moving on foot, but mostly to the fact that the French

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high command had no reserve "mass of maneuver" to throw against the gap. Eisenhower was not comparably in want when the Germans accomplished exactly the same kind of surprise breakthrough in the Battle of the Bulge in December, 1944.

On the tactical level there are, as a rule, few physical factors that favor the attacker over the defender, but many that favor the defender. The defender usually has the advantage of cover: he characteristically fires from behind some form of shelter while his opponent crosses open ground. As armies have increased the range, accuracy, and volume of their firepower, this advantage has tended to become more important, though in battle it has often been qualified by the necessity (real or presumed) for the defender to make local counterattacks where the opponent has temporarily gained an advantage.

For such reasons, even the most enthusiastic exponents of ground offensive doctrine in modern times have considered a decided local superiority of some kind to be essential to the launching of a tactical offensive. It has been considered one of the major advantages of the strategic initiative that it enables the shrewd commander to choose the time and place for the battle, and in so doing to achieve a tactical superiority at that place, even when his over-all superiority is not commanding and is possibly even nonexistent. That is the theory

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anyway, and historically it has often worked. Of course, it has almost always worked better -- certainly more continuously and smoothly -- where the side that held the strategic initiative enjoyed also a considerable over-all superiority.⁴

The air attack is intrinsically and radically different in all the above respects. In form, it consists not of a series of relocations of one's force, as is true of the advance of an army, but of a series of raids, each of which is incredibly swift in execution and completion as compared with movements on land or sea. They could be called swift in Douhet's time, and are much more so now. They are subject to no canalization by features of terrain. They have not only a wide latitude in choice of routes between base and target (within the limits of the range of invading aircraft), but they also have a choice of altitudes which can add tremendously to the bafflement of the defender. The invaders may have the capability to come in so high that the defender's interceptors

⁴ A striking example from the naval history of World War II is seen in the contrast between the six-month-long and frequently-critical campaign for Guadalcanal in the latter part of 1942, when we insisted on seizing the strategic initiative before we had developed any clear naval superiority in the Pacific, and the quick decisiveness with which we were able to take islands of comparable size and garrisons in all succeeding campaigns, when we enjoyed a commanding (and steadily increasing) over-all naval ascendancy. See Bernard Brodie, Guide to Naval Strategy, 3rd ed., Princeton, 1944, pp. 123-127.

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either cannot reach their elevation at all or cannot maneuver there; or they may choose to come in so low that his radar detection systems fail.

Thus the problem of interception has always been a difficult one to solve. It was especially so before the advent of radar, and now the difficulties are again rising as a result of the steadily mounting speeds of attacking planes and the development of various devices for confusing search radar, despite marked concurrent advances in the gathering and transmission of radar data as represented in the SAGE system.

Also, air combat offers nothing comparable to the cover afforded by features of the terrain, including man-made earthworks, which in ground war favor the defensive. Defense through air combat is inherently paradoxical, for the defending plane is an interceptor that can engage the offensive bomber only by attacking it. Being designed to fight over relatively short distances rather than to carry bombs over long ones, the fighter, though economizing in over-all dimensions, has usually been able to outrun, outmaneuver, and outshoot the bomber. But its advantages in one or more of these respects have often been only marginal. With the speeds of the modern interceptor tending to enter well into the region of the supersonic, its maneuverability at high altitudes may in fact be much inferior

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to that of the bomber it is attacking, because of the high wing-loadings which such speeds normally require.

There are, to be sure, certain contrary considerations. The defending interceptor is usually easier to replace than the larger bomber, and interceptor pilots forced to take to their parachutes are more likely to fall in friendly territory and to fight again than are the crews of downed bombers. Thus, if the defender is not caught too short-handed to begin with, is not too inferior to his opponent in inherent power or "war potential," and manages to protect the means of building his fighter planes and other defenses, he can expect during a campaign to build up his fighters more rapidly than the attacker can build up his bomber forces. The antiaircraft gun which contributes to the defense is not generally expended in action, so that its numbers and effectiveness grow in the course of a campaign.

The factors just described were dominant in the months during and following the Battle of Britain in 1940-1941. They were also present in the Allied air assault on Germany, but two major elements served in the latter case to upset the trend favoring the defender and to give the victory to the attacker. First was the fact that the two sides were far from comparable in the resources they could throw into the air

struggle, especially after Germany had become enmeshed in Russia. Not only could the Allies take their losses and still keep their bomber forces growing, but they were also able toward the end to pour vast numbers of long-range fighters into the air battle as cover for their bombers. It was these invading fighters more than any one other thing that broke the back of the German air force.

The second factor that shifted the scale in favor of the Allies was, under the conditions of World War II, much less important, but it was the one on which Douhet had banked. Because he felt that a relatively modest weight of bombs could destroy the enemy air defenses and air-defense industries, the fact that some bombers could always get through any air defense was to Douhet absolutely crucial. Those that got through would make the job much easier for the next wave, and that wave for the one following, and so on. And while World War II proved that Douhet's reliance on that principle was vastly excessive, in the end the successful bombing of the German oil industry did help to ground the remainder of the German air force. Presumably in a future war the use of nuclear weapons will make the victory of the air offensive over the defense much more quick and certain than previously. But the issue is complicated by the fact that the process works both ways:

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a concurrent counter-offensive would also benefit from the introduction of nuclear weapons.

Defense against hostile missiles in all forms of warfare, whether on land, sea, or in the air, has always basically consisted of a combination of two things: first, measures to reduce the number of enemy missiles thrown, or to spoil their aim, by hitting the enemy as he attacks (i.e., active defenses); and secondly, ability to absorb those missiles that actually strike home (i.e., passive defenses).

A naval force under air attack during World War II sought to avoid being hit by dispersing and maneuvering of ships, and relied on armor, compartmentation, and "damage control" activities in the individual units to minimize the damage of the hits received. These were its passive defenses. But all the while the naval force was shooting at the enemy planes attacking it, to their constant discomfort and frequent destruction. Fewer bombs and torpedoes were released against it, and at much longer ranges, than would have been the case had this firepower comprising its active defenses been lacking. Naturally, this combination of active and passive devices sometimes proved adequate and sometimes not, depending on circumstances and luck, but certainly one's chances for survival were better for having a defense.

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However, our example stresses the tactical situation. The old dictum that "the best defense is a strong offense" emphasizes the strategic idea that by taking the offensive a nation can forestall the enemy's blows and gain the advantage of hitting him at a time and in a manner for which he is least prepared. This idea is essentially an expansion upon the conception of active defense; but it is distinct enough so that it ought to be called by another term which dispenses with the word "defense." We might call it the idea of "security-through-offense."

All these considerations apply in air as well as in land and naval warfare, with, however, at least one major distinction. In ground warfare, force composition and tactics of fighting need not be markedly affected by whether one is on the strategic offensive or defensive. The target in either case is the enemy army. In air war, the forces involved and the methods of fighting are wholly different between the offense and the defense.⁵ In strategic air war, defensive

⁵ In naval warfare, which falls somewhere between air and ground war in these respects, the offensive takes the form of asserting command of the sea in a critical area, and of efforts both to expand the area of effective command and to increase the degree of naval control within that area. "Command of the sea" is in turn best defined as ability to use the sea for one's own shipping and to deny it to the enemy. The instruments for asserting and

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fighting is done with missiles fired from the ground or from fighter planes operating on, over, or near home or friendly territories; offensive fighting, on the other hand, is done by bombers releasing bombs over targets on enemy territory which may be on the other side of the world.

There are several important consequences of this difference between air and ground war, one of which affects the basic character of force organization. Since in ground warfare it is in general the same kind of army that assumes the defensive or goes over to the offensive, a commander's bias in favor of an offensive strategy may be only modestly reflected in the kind of field forces he asks for. But a comparable predisposition in the air war affects fundamentally the forces that the air commander requests.

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exercising command on the one hand, and for disputing it on the other, do tend to differ -- the former pursuit usually requiring a heavy commitment, among other things, to escort vessels for the protection of one's shipping, and the latter usually making much heavier demands on the use of raiding-type craft, especially submarines. Thus, naval war presents the paradox that the side that asserts command (i.e., the "offensive") appears to be engaged mostly in defensive activities against the opponent's raiding attacks. Such was certainly the character of the crucial Atlantic campaigns in both World Wars. The key to the paradox is that the fighting mostly concerns a value -- i.e., retention of ocean-going commerce -- of which the inferior side has already been deprived.

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Obviously, the commitment to the offensive will entail first of all a predilection for bombers rather than interceptors, but it is likely also to go far beyond the choice of aircraft. It might, for example, affect the character of the air-base structure. A complex of operating bases is very expensive to build, and it becomes more expensive as its designers attempt to provide protection against enemy attack either through surplus bases for dispersion of aircraft or through the "hardening" of bases by putting shelters around aircraft and important facilities. The extra cost of such additional protection comes out of funds which might otherwise be spent on more aircraft. The temptation to those who think in terms of the offensive is to rely chiefly on initiative to ensure getting off the ground on time, and to put the extra money into additional bombers to ensure sufficient survivors in the event of attack. The charge "Maginot mentality," with its connotation of cravenness and futility, can go a very long way toward stilling doubts about the wisdom of relying for security upon initiative rather than shelter.

In time of crisis, the offensive predisposition of the force structure will tend to induce conformity with the ideas that molded it. There will be pressure upon the government to guarantee that its forces will hit before being hit, just as

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in 1914 all the European general staffs pressed their respective governments to guarantee the security of mobilization by getting it started soon enough. Of course, such pressure is not going to be unresisted, and there is a high probability that it will be resisted successfully. A military planner should not rely for the security of his forces on a national initiative that will depend on governmental decisions and actions over which he can have no real control. It cannot be too strongly stressed that governments are rarely if ever monolithic in a way that encompasses both the military and civil branches; and democratic governments are the least so of all.

Let us now divide the air-defense problem into its separate components and consider each one in turn. We have seen that defensive activities are of two kinds: the active defenses, which consist of shooting at enemy planes, and the passive defenses, which involve mainly hiding, shielding, or dispersing the targets. To these unequivocally defensive functions is added the security-through-offensive mission of the strategic air forces, now commonly called the "blunting" mission, which seeks its targets on enemy ground in the form of grounded aircraft, airfield installations, and the like, including enemy nuclear stockpiles if accessible. The blunting

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mission is operationally almost indistinguishable from the other offensive missions of long-range bombers. It differs from them mostly in the nature of the targets primarily selected for destruction and in the special value of speed in accomplishing it.

However, before we discuss each of the first two methods of defense, we should take up a problem that is common to both, and that also affects the blunting mission: that of getting some degree of warning of impending enemy attack.

The Problem of Warning

Warning is the key to the entire defense problem. Our expectations concerning what warning we will get largely determine both what kinds of defenses (including the warning system itself) we think are worth spending money on, and how good they will be. If we could count with very high confidence on having three or four hours' warning of an impending strategic attack, and if the enemy knew that our confidence was justified, we should probably have nothing further to worry about with respect to that kind of attack. That much time would suffice to get most of the aircraft of our Strategic Air Command off the ground and out of harm's way, and the enemy would have to count on a retaliation so powerful (assuming his own defenses

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were not magically impenetrable) as to be utterly unacceptable as the price of an attack on us. The anticipation of retaliation would therefore surely restrain his hand, and we would have strategic deterrence operating with nearly perfect efficiency and reliability.

Without pausing now to dwell on the qualifications and exceptions to this idea (or on the question of its feasibility), let us note that it highlights two basic principles about defense in general, and about warning in particular. First, whatever else it may be possible or desirable to defend, it is absolutely essential to defend one's retaliatory force, or a substantial portion of it. Known ability to defend it in fact constitutes the only thing (short of complete world-wide nuclear disarmament) that is potentially a complete and perfect defense of everything else. Conversely, of course, a conspicuous inability or unreadiness to defend the retaliatory force must tend to provoke the opponent to destroy it; in other words, it tempts him to an aggression he might not otherwise contemplate. How can he permit our SAC to live and constantly threaten his existence, if he believes he can destroy it with impunity?⁶

⁶ The fact that this question need not be peculiarly one-sided in its application is attested to by the one-time existence in this country of a "preventive war" school

Secondly, if there must be a choice, a reliable and unequivocal warning measured in hours is far more valuable than a much longer period of warning that cannot, by its nature, be reliable and unequivocal. The longer-term warning is what we tend to expect from secret intelligence, and it is reasonable to suppose that if we rely upon such a warning system to trigger action when trouble is brewing, we should probably have to depend on indicators that are fairly equivocal.

There is in these matters a stupendous difference between hindsight and foresight. The intelligence indicators of the Japanese attack at Pearl Harbor could hardly look more unequivocal to the historian who studies them now, especially in view of the information we received through the cracked Japanese codes. But they were not read as such by the appropriate people at the time; they did not then point the finger at Pearl Harbor rather than elsewhere. This was so for a number

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of thought. Nevertheless, Nathan Leites has developed the thesis that in Bolshevik ideology there is a special compulsion to destroy the opponent's capability to destroy oneself, and whether or not this compulsion is acted out depends entirely on the prevalent estimate of feasibility. Cf. RAND Report R-239, A Study of Bolshevism, Santa Monica, May 1, 1953, chapter xvii and passim.

of reasons which, however, did not include anything that one could call obtuseness. The few persons -- few because of extreme security precautions -- who had the opportunity to read the decoded Japanese messages included men of outstanding intelligence and dedication, and they were as good a group as we ever are likely to have in comparable positions. But they were too harassed by other preoccupations, including the whole European war and the affairs of the Atlantic, to concentrate their attention on the suggestive items of intelligence that were somewhat spasmodically brought to their attention.⁷

It is an old story that one can pay a great price for security when it takes the form of limiting vital information to a few highly-placed persons who do not have time to think about it. The responsiveness of U.S. government agencies to war indicators has no doubt been improved over the Pearl Harbor situation by appropriate organizational changes. But one should not forget the powerful predisposition to believe that an existing peace will continue. Modern war is so hideous in its immediate effects, and so huge a gamble, that it is

⁷ See in this connection the forthcoming RAND study Signals for Pearl Harbor, by Roberta M. Wohlstetter, chapter iv and passim.

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always difficult for any normal person to believe that someone or some group could be planning to start one soon.⁸

During the cold war, the Soviets have almost succeeded in suppressing this bias among some Americans, but the mere passage of time would tend to restore it even if there were no shift to relatively benign behavior on the part of the Russians. One gets used in time even to cold war, and the more one gets used to it the more one appreciates how different it is from hot war.

Paradoxically, it is their very attachment to the offensive spirit that creates a strong impulse among the military to disbelieve that the enemy may have comparable attachments, and that he may therefore attempt to initiate hostile action. Too much worrying about what the enemy may do is almost by definition "defensive thinking," which is considered all right for specialists with specific defensive assignments, but dubious for war planners or theater commanders. It is interesting that the precautions actually taken at Pearl

⁸ However, the degree to which Stalin was able to deceive himself in 1941 about the peacefulness of German intentions, despite specific warnings from Churchill and Roosevelt as well as his own functionaries, reflects a degree of willful blindness which, historically, is highly abnormal. It would be difficult to find another instance where such positive warnings of attack were so flagrantly disregarded. See in this connection Khrushchev's secret speech before the 20th Congress of the Communist Party of the Soviet Union. (The New Leader, Special Supplement, July 16, 1956; pp. S-36 to S-43.)

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Harbor before the attack were exclusively concerned with sabotage, which is essentially nonmilitary in form. Perhaps for that very reason it is regarded as not unbecoming to fear it.⁹

The utility of long-range warning depends not alone on its reliability or degree of equivocality but also on what one wants to do with it. It is one thing to use it to trigger an attack that will anticipate and forestall the enemy's attack, and quite another to use it simply to intensify alertness to shorter-term warning and to take other elementary precautions of a strictly defensive nature. These are differences of basic attitude toward the nature of the problem. There is a school of thought that argues that our whole system of defense must be based on the concept of anticipatory attack, that is, of an attack provoked by, yet preceding, an enemy attack; one wag has described this as the principle of "I won't hit first unless you do." The probability that such fine anticipation will be realized is, of course, ridiculously low.

⁹ The responsible commanders at the time could not know, as we know now, how empty was the threat of sabotage from the large population of Japanese descent on Oahu. But it is characteristic of the perennial fear of sabotage that the threat is almost never quantified by those who express fear of or make preparations against it. The enemy's "Order of Battle" is the gauge of his military capabilities, which one wishes neither to overrate nor to under-rate, and the value attached to it by intelligence operatives is extremely high. But no one thinks of devising an "Order of Battle" for prospective saboteurs.

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Unless a government is willing to be the aggressor -- in which case it surely does better to forget about warning and to choose its own time to attack -- the "anticipatory attack" type of response implicitly requires that warning be unequivocal. But early warning is almost certain to be equivocal. Only if the enemy is very clumsy or stupid, or both, will he signal well in advance his intention to attack.

There may be no lack of early, equivocal warning. It is appropriate in the nuclear age to be alert to the possibility of deliberate unrestricted attack unheralded by any apparent worsening of relations. But it is also appropriate occasionally to remind ourselves that that sort of thing has never happened in modern times between great nations, although it has often been feared. The factors militating against its happening remain at least as powerful now as they have ever been.

We should note also that the considerations determining the utility of short-term warning are different now from what they were in World War II. In that war, radar warning of enemy approach was useful primarily because of the assistance it gave to defending fighter groups. It permitted the bulk of interceptor aircraft to remain in advance readiness on the ground, instead of wasting their limited flight endurance in

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"stooging" aloft; and it greatly assisted airborne fighters to make contact with the enemy. In that role the British radar screen at the time of the Battle of Britain proved to be one of the important technological surprises of the war. But it mattered relatively little if air-raid sirens sometimes did not sound until bombs were already falling. Few lives or aircraft were lost by those unannounced first bombs.

Today, however, the first bomb is likely to be the only one that a community or an air base will hear or feel. One major object of short-term warning is still to aid interceptors or other active defenses, but probably a greater object is to get out of harm's way whatever targets are movable: people, vehicles, and especially the crews and aircraft of the Strategic Air Command. The reason we want to save the latter is not that we are interested in retribution for its own sake, but that the whole deterrent value of our long-range bombing force rests, as we have already noted, on its known immunity to destruction by surprise attack.

The rapidly advancing speeds of bomber aircraft are tending to defeat the utility of search radar, which is intrinsically incapable (because of its line-of-sight operating limitations) of compensatory advances in range. It is necessary, instead, to push the actual stations farther forward. In Europe there

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is often too little space to do this. But the United States, among the major powers, is uniquely able to surround itself with advance warning screens to gain a few hours of warning before hostile planes can cross its main frontiers.

The United States and Canada are presently completing three main radar lines in the north. The closest, sometimes called the Pinetree Line, lies in some depth along the Canada-United States frontier. Farther out is the Mid-Canada or McGill Line. And in the arctic wastes, roughly along the parallels between 68° and 70° north, is the DEW (Distant Early Warning) Line. The flanks of these lines continue out to sea through the use of picket ships, "Texas Towers," and airborne search radar carried in large routinely-operated military aircraft. Buttressing these electronic alarm systems, at least in the more temperate climates, is the Ground Observer Corps of volunteer civilians.

Although the costs of erecting and operating this system are bound to be quite substantial, even as national security budgets are now reckoned, the result is far from foolproof. An opponent could attempt to confuse or desensitize it in its outer reaches by "spoofing," that is, by deliberately penetrating it simply to register false alarms. We know also that there are various devices, familiar from World War II,

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for confusing a radar screen (e.g., "chaff" or "window"); and new ones will no doubt be thought of. There is also a great deal of legitimate commercial traffic in peacetime, which presents an enormous discrimination problem. Finally, radar screens may offer no useful warning at all against missiles or aircraft which may be launched from submarines and which may have ranges sufficient to penetrate 500 miles or more inland, or against very-long-range ballistic missiles. And they are likely also to prove inadequate against low-flying aircraft.

Not much more can be said descriptively about the longer-term warning system discussed previously, which depends on intelligence indicators. It is an area quite properly shrouded in close secrecy, so that those who are not actually dealing with the relevant operations cannot judge whether there is much or little to be expected from them.

But the problem of warning is not only one of getting relevant information, whether from radar screens or secret operatives; it is also necessary to know how to handle the information when it comes. A warning system must be sensitive enough to be promptly and reliably triggered at the appropriate time, which means that it has to be sensitive enough to produce occasional false alarms. Yet it might become politically intolerable for the false alarms to be too frequent, especially

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if the response to every one of them were elaborate enough to create considerable disturbance in the population. The "appropriate time" will come only once, if it comes at all, and the problem of maintaining a fine balance between alertness and calm will, if we are lucky, prevail over many years. During those years, the permitted reaction time will become steadily less, until the long-range ballistic missile reduces it to a hard minimum so small as probably to allow no time for counteractions that are not fully automatic.

Active Defenses

By "active defenses" in air war we generally mean two major categories of instruments: the interceptor aircraft with the system of weapons it carries aloft; and the various latter-day derivatives of the antiaircraft gun, which is to say mostly ground-to-air self-propelled missiles. In the projected long-range, unmanned, expendable interceptor, such as the Bomarc missile, the two categories tend to merge. Both categories have undergone impressive technological development since World War II, but at the usual price of greatly increasing unit costs. Thus steeply ascending costs make it increasingly burdensome to provide the necessary numbers of weapons to assure good defense.

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Although it appears that in the net active defenses have gained considerably, and are continuing to gain, in their ability to cope with the conventional manned bomber as an invading aircraft, this gain has been far more than offset by the change in the weapons that the bomber carries. The problem of defense against bombers carrying thermonuclear bombs, or even fission bombs, is simply not in the same category as that of defense against bombers carrying the old types of explosives or incendiaries. The basic difference lies in the rate of bomber kills that the defender must consider necessary and the attacker tolerable; from this difference, which is an extreme one, all sorts of other differences follow.

The modern interceptor aircraft costs between one-half million and one million dollars per unit. In level flight and at higher altitudes, it moves at speeds close to, or well above, that of sound. In its "all-weather" form it carries aloft an AI (airborne intercept) radar, and all models will probably use some form of radar in fire control. The armament used is already vastly superior to the World War II kind, and is getting better. The new interceptor will fire explosive rockets (air-to-air self-propelled missiles), guided and unguided, of 2.75-inch caliber and larger.¹⁰ It is possible

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An excellent unclassified survey of aircraft armament in use and under development at the time of writing is

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also that small atomic warheads will be provided in the future. The fighter is an impressive and a beautiful object. Why then do experts usually attribute to it an effectiveness that to the layman seems astonishingly low?

The answer lies in the fact that an effective kill of an enemy bomber depends on a sequence of discrete operations, each of which introduces a chance of failure. The probability that each stage will be successfully accomplished is of course less than 1 -- in some stages much less -- and to get the probability-of-success for the entire sortie (measuring success by some such index as the killing of a single enemy bomber), the various fractional values representing the success-probabilities for each of the separate stages have to be multiplied together. The product is bound to be a smaller fraction than any of the multipliers.

Let us briefly consider what happens to a single squadron of twenty-five interceptors. At any one time during routine operations a certain proportion of the planes will be undergoing a sufficiently extensive servicing to make them unavailable for dealing with a surprise strike. Of the remainder,

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contained in "Aircraft Armament," Flight and Aircraft Engineer (London), January 28, 1955, pp. 105-110, 114-122, 129.

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only a small proportion will be in an advanced state of readiness -- i.e., with crews standing by and able to take off within five minutes -- though increasing proportions will be available as the warning time is increased. Thus the availability factor will vary importantly with the warning time. The more advanced the position of the bases, however, the shorter the warning time is likely to be.

Of those planes that take off in time, a certain proportion will abort for some mechanical reason. Others will abort because of some gross pilot error. Even then, a plane properly vectored out to the location of the enemy bomber may fail to make its own AI detection, or convert a detection into a proper firing pass. The former is especially likely for aircraft which are not equipped for all-weather operation, and, under modern speed conditions, the latter is a considerable probability for any aircraft. At best, the interceptor can count on a single firing pass, which will very likely be a collision-course intercept from abeam requiring a difficult and fleeting deflection shot rather than the stern-pursuit kind of shooting common in World War II. The latter condition does carry with it one advantage over World War II conditions: the fighter is more likely to survive the bomber-fighter duel. For fighter survival remains another factor to be reckoned with in the calculation.

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Finally, if everything has gone well up to this point, the functioning of the fire-control apparatus and of the armament itself has to be equal to the extremely severe requirements laid upon them. Incidentally, the planned use of atomic warheads in airborne armament is intended, not to enable an interceptor to shoot down more than one plane at a time, as one might suppose, but simply to increase the kill probability against the single plane at which the interceptor makes its (usually single) firing pass.

Thus, if we should find that of our original twenty-five interceptors only one or two have actually shot down enemy bombers, we might have no justified fault to find with the performance, though we should indeed be entitled to regard the result as unsatisfactory.

We have so far assumed that the interceptors will be properly designed for the task that awaits them. But the enemy may steal a technological march and use bombers that arrive at altitudes which our interceptors cannot even reach, let alone operate at effectively. And if we design an interceptor for extremely-high altitude performance, which inevitably means increasing the cost per unit and sacrificing lower-altitude performance (partly because of requirements for larger size and lighter wing loading), we might find that the enemy

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elects to come in "on the deck," this is, at very low altitudes, where he may hope to escape radar detection. Inevitably, the attacker will be using all the electronic countermeasures (ECM) his scientists make available to him for confusing our search, airborne intercept, and gunnery radars.

The enemy can also avail himself of the ancient prerogative of the attacker to concentrate his forces, in both space and time, and thus overwhelm the inevitably dispersed defenses. The interceptor does not represent "local defense" in quite the limited way that the antiaircraft gun does, but in terms of defending an area as large as the United States and adjacent Canada, its legs are pretty short. The requirements for very high performance and for a size modest enough to make quantity procurement possible limit the fighter's opportunity to extend its legs. What is more, we must remember that the utility of range in the interceptor depends also on the time available for tracking the enemy bomber. There is no use building more range into the interceptor than our radar system will ever permit it to utilize.

In World War II the defending fighters were effective enough to oblige the German and British air forces to do their bombing at night, when their bombing accuracy was very much impaired; (the U.S. Air Force held to daylight bombing, but,

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after a few disasters, had to put long-range fighters in escort). The modern long-range bomber, with its almost complete reliance on radar navigation and bombing, is about as effective at night and in bad weather as at any other time. The influence which the interceptor may still have in forcing the invading bomber to elect night approaches therefore brings it much less credit than it had in World War II. The fighter must now actually shoot down the bomber before it reaches the target. And even if the bomber is shot down short of its target, a thermonuclear bomb in its hold may be set to go off at or near contact with the ground, in which case it will still do a lot of damage either directly or through radioactive fallout.

Yet, despite these many drawbacks, the interceptor furnishes the only means, other than the projected Bomarc missile, of reaching out for the bomber before it can reach the vicinity of its target.

The other kind of active-defense weapon is the missile fired from the ground. The scorn in which Douhet, Mitchell, and their followers held the antiaircraft gun followed from an understandable inability to foresee the marvelous electronic fire-control devices that would be perfected in time for use in World War II. Before the end of that war we had gun

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directors (especially on naval vessels) that could fix on an aircraft target by radar, follow that target, and automatically compute the proper lead for the antiaircraft guns which were moving in complete synchronization with them. The guns, in turn, fired shells (of 5-inch caliber or larger) armed with the proximity or "variable time" (VT) fuse, which was itself a miniature radar sending out impulses and responding to their echoes.

Progress since has moved mainly in the direction of substituting guided, self-propelled missiles for the gun projectiles.¹¹ The Army NIKE, which is the prototype of this family of weapons, has enormously greater range (approximately twenty-five miles) than any antiaircraft gun. It also has much greater killing power as a result of its large size and its ability, under automatic command guidance, to adjust to evasive maneuvers of the target plane. It will no doubt develop further in range, and it may increase its lethal radius or killing power by adopting an atomic warhead, though its accuracy may make that

¹¹ The conspicuous exception is the "Skysweeper," a 75-mm. radar-controlled automatic gun, which is especially useful against low-flying aircraft. But further development of the type is rendered doubtful by the apparently inherent combination of very limited range and high unit cost.

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unnecessary. So far so good. Some regard the NIKE-type of missile as already worth more on a dollar-for-dollar basis than the interceptor, and as definitely the more promising of the two for the future.

On the other hand, the antiaircraft missile has certain grave limitations. First, while it is of remarkably long range as compared with a gun, it has very short legs as compared with an interceptors. This means, among other things, that it is an inherently dispersed kind of weapon, the units of which tend to be fixed not only to the defense of a single area but to a single quadrant of that area. The NIKE installation that defends Chicago from the south would hardly be of much help against planes approaching that city from the north.

The site of a NIKE battery is not easily concealed, and the locations of established ones will no doubt be well known to the enemy. The invading bombers would know pretty well what it would take to saturate the NIKE defenses of any given area. Manned bombers are also likely to develop means of remaining outside the range of local defense weapons while shooting in supersonic air-to-surface missiles to destroy the target. Or they might even (conceivably though improbably) rely on lethal fallout rather than blast or heat to make cities untenable, thus having only to drop their

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bombs in the countryside beyond the range of local defense missiles surrounding cities.

The NIKE is further limited in its rate of fire. Each battery of launchers has but one radar-director system, which must remain fully occupied with one missile for the full time of its flight. If each missile in flight takes two or three minutes to get to its target, the number of missiles that one battery can fire at any one enemy formation cannot be large. Director systems and even whole batteries can be multiplied, of course, but they are not cheap.

Above all, any system that is heavily dependent upon radar (the NIKE uses radar for search or "acquisition" of the target, for target tracking, and for missile tracking and guidance command) is inherently subject to confusion by appropriate measures.¹² The answer to enemy electronic countermeasures is counter-countermeasures; but the attacker has the initiative, and available learning time for the defender is going to be short or nonexistent. Naturally, the limitations and weaknesses characteristic of NIKE are not necessarily

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See unclassified description of NIKE, with photographs, in "NIKE's Nest," The Army Combat Forces Journal, January, 1955, p. 16f.

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inherent in all antiaircraft self-propelled missiles. For example, a missile with a built-in homing device might be free of the peculiar rate-of-fire limitation to which NIKE is subject. Also, it is probable that unguided missiles thrown up in barrages can supplement the guided ones.

One must repeat, however, that the kinds of defenses mounted against high-level attack are generally of not much use against bombers that stay roughly under 1,500 feet during most of their approach to target. An additional low-level defense capability therefore has to be provided, at great additional cost.

Our observations have so far tended to stress the limitations of active air-defense instruments. But there are also a few general observations to be made on the positive side. First, if the active defenses succeed only in obliging attacking bombers to concentrate in groups against individual targets, thus depriving them of the freedom to attack a separate target with a single aircraft, much has already been accomplished. In World War II, even where defenses could be disregarded, planes had to concentrate or converge upon individual targets in vast armadas in order to drop enough bombs on those targets. With atomic and especially thermonuclear weapons, one bomber over

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target is usually quite enough. If it were not for active defenses, therefore, there would be nothing to keep an attacking bomber fleet from spreading out over the land to destroy every target on its list in one strike. But if the defenses oblige it to assume tactics which restrict it to, say, one-fourth of its target list for the first strike, perhaps much of the remaining three-fourths can be permanently saved, especially if one's own surviving bombers are meanwhile reducing the enemy air force.

The above argument, if sound, is no doubt enough in itself to justify a very large expenditure on active air defenses. Their existence greatly raises the requirements for the enemy's strategic bombing force. He must raise and maintain a multi-strike capability, which is disproportionately more expensive than a one-strike capability.¹³ Above all, his confidence in his ability to carry through a successful surprise attack should also be disproportionately reduced.

¹³ A one-strike capability means that an attacker need not retrieve his bombers, whatever provision is made for the rescue of crews (or their temporary internment in neutral territory). Thus, one-way ranges are adequate and there is no need for air-refueling tankers. A multi-strike capability means that one must retrieve a high percentage of dispatched bombers (thus reducing the attrition-tolerance level) and bomber designs must provide for something like two-way ranges as well as for a large supporting force in tankers. What is more, regrouping becomes a difficult problem in a multi-strike capability.

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But, of course, there is not much solace in raising the enemy's requirements, if he is still able to meet them. And even if his first (inevitably devastating) strike is significantly confined in its effects, we have to allow for subsequent strikes if we cannot meanwhile succeed in destroying his air force. These facts should incidentally remind us that defenses that are enough to worry the commander of an attacking force do not necessarily warrant comfort to the defender. The real value of one's active defenses lies, as we have suggested, in what they contribute to deterring an attacker, if they are effective in that respect at all.

Large countries such as the United States or the Soviet Union can by dint of great expenditures and much ingenuity devise methods of active defense which, with luck, will exact high attrition of attacking bombers, at least of the manned type. But the destructiveness of the nuclear weapons carried by the bombers that will get through any defense has grown to the point where further growth seems almost uninteresting. Also, the passing of time brings us inexorably closer to the advent of very-long-range ballistic missiles that almost defy all existing conceptions of active defense.¹⁴ If the cause

¹⁴ Apart from the technical problems involved, which are enormous but at least in theory not insuperable, defenses against ballistic missiles are likely to require a kind of

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of active defenses is thus not altogether lost, its prospects for the future are scarcely bright.

Passive Defenses

Active defenses seek to reduce enemy bombing by downing the aircraft carrying the bombs. Passive defenses, on the other hand, seek to minimize the effects of those bombs that are dropped. We have seen that active defenses can almost always be defeated regionally by a strong attacker, at least by sheer saturation, if not also by surprise. In Douhet's words, "the bomber will always get through." This fact suggests the need for passive defenses.

There is also a special quality about passive defense which suggests in reverse a quality comparable to saturation in the attack. Just as saturation is in theory an answer to any kind of active defense, so the removal or sufficient hardening of a target is theoretically an answer to any kind of attack. In practice, of course, many attractive targets do not lend themselves to protection by passive means. But once the special quality of passive defense is grasped -- once the curse

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automatism of response that may prove politically unacceptable in peacetime. That will be especially true if anti-ICBM missiles have to carry nuclear warheads.

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is taken off the term "passive," that is -- it may be discovered that much can be accomplished by reasonable efforts.

Passive defenses fall into one or more of three different patterns: first, measures involving concealment of the target (including devices designed to deceive or confuse enemy bombers); secondly, measures involving some form of armoring or hardening of the target (e.g., provision of underground shelters); and, thirdly, measures involving removal or dispersion of targets. Perhaps one could add stockpiling of replacements for things, such as aircraft, which are likely to be enemy targets, but replacements also have to be dispersed or otherwise protected in order to survive.

There are several other generic differences between active and passive defenses. The former tend to be defenses of a locality rather than of an object. They comprise interceptors and anti-aircraft armament, which, because they are detached from the targets they defend, can be relatively easily shifted on short notice.

Passive defenses, on the other hand, vary with the nature of the objects they protect, and are usually quite intimately integrated with those objects. An air-raid shelter is fixed in a way that an interceptor aircraft is not; a shelter suitable for covering people is not suitable for protecting the equipment

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of an oil-refinery plant. Thus, in order to provide meaningful passive defenses, governments have to decide well ahead of a crisis just what objects they are going to protect, and how thoroughly they will do so. Such decisions are not likely to be easy, either conceptually or politically.

There is also an enormous difference in minimum cost. Active defenses, to be of any use at all, require a very considerable minimum expenditure, one measured in billions of dollars annually. Simply to provide a "no-holes" radar warning network, without which active defenses are essentially useless, is itself a considerable undertaking. In passive defense, on the other hand, much of value can be done at relatively little cost. The dissemination of information to people about what to do in the event of attack, for example, costs relatively little, but might be invaluable in a crisis. Of course, it is also easy to think of extremely expensive passive measures, such as putting military forces, populations, or large industrial facilities underground. However, the fact that such measures are costly is not in itself sufficient to establish that they are inappropriate. We have already several times stressed the importance of making SAC secure, and doing so is bound to involve considerable outlays for passive defense.

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The things that one wants to protect through assorted measures of passive defense may be roughly grouped into three general categories: people, production capital, and military forces in being. These are of course not mutually exclusive categories. People require a certain basic supply of consumer goods, and, in the longer run, enough production capital to meet at least the recurring needs of bare subsistence. People also represent cherished political and social institutions, which, however important, are imponderables and therefore defended, if at all, only by defending people and their property. Similarly, extant military forces always comprise personnel, in addition to material objects and such nonmaterial elements as group integrity. Yet, despite overlapping, the rough threefold classification seems a useful one for our purposes.

Despite our previous remarks about the absolute necessity of protecting our SAC, even if everything else must go undefended, it still remains true that of our three general categories only the first, people, represents an end value. People are individually precious, regardless of how many or how few survive. The other two categories are means to an end, that is, they provide for the welfare and protection of the people.

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It is necessary to make this point, because military officers of undoubted decency and humanity have often permitted their remarks on defense needs to reflect an apparent unconcern with the desirability of saving human lives for their own sake. Calculations which embrace the possibility of gigantic casualty lists tend to induce in the people who make them a callousness that, however superficial, may be operationally important in planning. On the other hand, civilians of established wisdom and temperateness have sometimes expressed impatience at a scale of priorities in defense which explicitly and overwhelmingly favors military forces.

A permanent and comprehensive dispersal of existing industries would, to a large degree, automatically entail a comparable dispersal of population. The result, in effect, would be dispersal of our cities. The expected advantages of such a program are, first, that it would minimize dependence on the timely receipt of warning of enemy attack, and, secondly, that production capital would be protected along with the people who service it. The decisive disadvantages of urban decentralization are that it seems to be enormously difficult to carry out, both economically and politically, and that the protection gained even by a high degree of dispersal is hardly likely to be commensurate with the effort of achieving it.

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Capital and people are dispersed permanently in order to reduce the density of valued objects in any one target location. If the atomic bomb had remained of a power roughly comparable to the "nominal" weapon exploded at Nagasaki, a reasonably feasible kind of dispersal could have meant that more bombs, perhaps very many more, would have to be delivered by the enemy to effect a given amount of injury. Although it is likely over the short term to be harder for the defender to increase the number of targets than for the attacker to increase proportionately the number of bombs delivered, over the longer term the race would not have looked so bad for the defender, if weapon technology had remained at a standstill. Even if there were no final limit to the number of bombs an enemy could produce, there would certainly be a limit to the size of the delivery force he could maintain indefinitely during peacetime. And once hostilities broke out, that force would suffer attrition, especially if the aircraft comprising it could make repeated sorties to complete a bombing program.

But as atomic bombs, besides multiplying exuberantly in numbers, also increased in unit power, the attractiveness of permanent dispersion inevitably faded. With the coming of the H-bomb, potentially available in whatever numbers might be desired, and with discovery of the radioactive fallout effect

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of large-yield ground-burst weapons, it became clear that costly dispersion can to a large extent be countered by the very cheap expedient of delivering a vastly more powerful bomb. The combination of increased numbers and enormously greater power per unit gives the nuclear weapon a completely dispiriting lead in such a race. If a metropolis as naturally dispersed as Los Angeles can be effectively destroyed by a single weapon, we know that the forced dispersion of denser communities would have to proceed to much more drastic lengths than was previously thought necessary in order to be of any use at all.

A modified dispersal action that concerns itself only with the placement of new defense plants and the populations that service them is already being actively pursued by the United States Government, which holds a certain leverage of inducement in its methods of awarding defense contracts, and in the provisions for amortization in the income-tax laws. In a steadily expanding economy such as ours, significant effects of such governmental action should eventually be discernible in that part of it directly concerned with military production. This is cheap dispersal, even though it is relatively slow and only partial.

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But it is very easy to exaggerate both the cheapness and the benefits of such a program. Thus far, pressures for dispersal on the part of government agencies have not reflected any well-thought-out plan which sought, among other things, to anticipate weapons developments or the enemy's future capabilities.

The government has acted as though some of the more obvious vulnerabilities can be corrected even by unsystematic intervention. One such, for example, would break up the concentration of plants producing military aircraft in a single coastal section of southern California. That section may indeed be vulnerable, but the attack that eliminated the plants in it would almost certainly not be an isolated one, and it is doubtful whether plants situated anywhere in the United States could continue to build aircraft on a substantial scale after an all-out nuclear attack, unless far more drastic steps were taken to protect all industries related to the manufacture of military aircraft than have yet been contemplated. Meanwhile, forced dispersion could hurt not only the communities involved but the industries themselves (e.g., by causing the loss to research organizations of skilled engineers who would not wish to move), and could postpone the availability of new types of aircraft and missiles that we want to have on hand before

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any attack. There is, of course, no objection to free or unforced dispersal, such as results from normal movements to metropolitan suburbs, or from determination of new factory locations by the relative cheapness of land values outside big cities.

Nothing that has been said above should be construed as expressing objection to carefully planned, selective dispersion. On the contrary, certain limited segments of our polity and economy, particularly those concerned with the governance of the armed services during wartime, seem to cry out for such planning. The Pentagon, a prime target in itself, situated in a city which would be a prime target without it, forces one to ask whether the reasons for such a concentration of military leadership and authority in so exposed a place are really compelling.

Nor should objections to permanent industrial dispersion be interpreted to mean that there should be no preparations for temporary evacuation of cities during a crisis. If there were enough warning time, evacuation of cities to prepared locations would probably be at least a partially effective way of protecting our urban populations. Developments with respect to radioactive fallout make city evacuation less attractive as a defense measure than it once appeared; but it is probably

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true that ordinary dwellings, especially those provided with cellars, can furnish considerable protection if suitably equipped for a siege with foods and other supplies, including instruments for measuring intensities of radioactivity.

A wry hopefulness for the defense of civilians resides in the fact that there is no obvious reason for the enemy to destroy refugee populations in addition to the cities from which he has forced them to flee. On the contrary, he has every interest in burdening the opposing government with masses of utterly dispossessed and panic-stricken citizens. Corpses, by contrast, present few problems other than disposal.

There is, to be sure, a common tendency to regard every additional increment of injury inflicted upon the opponent as unquestionably a military advantage. But fortunately there always have to be scales of priorities in a bombing program. The kind of destruction that is perhaps too readily regarded as "bonus" damage if it follows from attacks against other objectives is not necessarily the kind that either belligerent seeks to accomplish or feels he can afford to accomplish if it requires a large special effort.

On concealment as a form of passive defense, only a few general remarks can be made. There is an enormous disparity

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between the Iron Curtain countries on the one hand, and the United States and its allies on the other, in the degree to which each camp permits target information for strategic bombing to be made available to the other. Except for a very few kinds of highly specialized military targets in the United States, the Soviet Union need employ no secret agents to get the information required to fill its target folders. It needs only a staff to select out the more germane data from what is openly and abundantly reported to it in numerous unclassified publications, including highly detailed maps, or from what is plainly visible to visitors who have a free run of the land. Regardless of how good our own intelligence may be, the Soviets can probably always be more confident of the adequacy and accuracy of their target information than we can be about ours.

Nevertheless, the disparity has clearly diminished as a result of the development of ever more powerful bombs. Even the Soviet Union can hardly hide the existence or location of its larger cities, and, with H-bombs available, that information may be all we need to maintain a very respectable deterrent threat. When it comes to the targets of the so-called "blunting" missions, however, that is, mainly the **opponent's** long-range air forces, there can hardly be any doubt that the Soviet Union must have a decided advantage in target information. How

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critical this disparity is only a few intelligence officers can tell, if anyone can, and they may be deceived. Of course, even perfect target information would not assure the Soviet Union the ability to destroy our SAC, so long as it could not be sure of denying us all significant warning.

There is another kind of concealment, which depends on the use of devices such as decoy targets (whether against visual or radar bombing) or radar-jamming. In this respect there need be no inherent advantage to the Soviet Union (or disadvantage either), but there may well be an inherent advantage accruing to the attacker, whoever he may be, as against the defenders, particularly with respect to the availability and utility of surprise.

Finally we come to the kind of passive defense called "hardening," of which the air-raid shelter is a typical example. It comprises putting a shield between the objects to be protected, whether human or inanimate, and the position of the bomb burst. Against the bombs of World War II, the function of the shield was to stop the bomb itself, its fragments, or missiles caused by the explosion, such as flying fragments of masonry. Against nuclear weapons, however, the shield must protect also against blast (usually measured in pounds of "overpressure" per square inch, abbreviated "p.s.i.") and ground shock, and, if the objects protected are persons or other living beings, against

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gamma rays emanating from the nuclear explosion. Anything sufficient to protect against blast and direct gamma rays will surely suffice against thermal radiation. Thermal radiation is, however, dangerous at much greater ranges than are blast or gamma radiation, and the same is even more true of radioactive fallout, so that some kind of shelter may be necessary even at very considerable distances from the point of bomb burst.

A thermonuclear weapon detonating on the ground will cause a large crater around the point of impact (the one at Bikini in the Ivy shot was over a mile in diameter), and we probably should write off any shelter in the area covered by such a crater. On the other hand, at very short distances beyond the rim, deep shelters would offer effective protection to people within them, and, with modest increase in distance, the amount of depth or thickness of shelter necessary to offer protection would fall off quite rapidly. Thus, on an over-all statistical basis, the chances for people in underground shelters even within cities to survive nuclear attack are sure to be very much greater than those of people in the same area who are not comparably protected.

There remains much that we do not know about the relevant problems. One of the only two nuclear bombs thus far dropped

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on cities caused a firestorm (at Hiroshima), and that one was of about 15 KT yield. People in shelters may be preserved from destruction by blast or gamma rays and yet perish from suffocation -- unless suitable provision be made for providing oxygen for the duration of a firestorm. There is also the problem of the intense radioactive fallout in the near proximity of ground zero, which may conceivably prevent egress from the shelters for days or even weeks.

These considerations qualify the value of shelters but do not negate them. However, there is the further problem of seeing to it that people are inside the shelters when the bomb explodes. Inanimate objects of high strategic importance can be stored indefinitely in highly bomb-resistant shelters -- as no doubt most of our stockpiled nuclear weapons already are -- but people cannot be. This is a problem of warning, though the warning time necessary is obviously less than that required to conduct a successful evacuation of cities.

If the strategic bombing of cities at the onset of war were not a foregone conclusion, the government would probably want to persuade people to stay in the cities. Adequate shelters and a promise of adequate warning might well be a necessary part of the inducement. Moreover, it is possible that having shelters available to which to send its people

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might make a government more willing to take the initiative in a crisis. Such initiative would for the time being make the question of warning irrelevant: it is one's own decisions rather than the enemy's that trigger the resort to shelter.

Provision of funds for the elaborate shelters necessary within cities would have to proceed in the face of the ever-recurrent suspicion that evacuation would probably be preferable anyway, provided, of course, that the public apathy or skepticism which at this writing has effectively inhibited either defensive measure could first be overcome. Part of that apathy in the city dweller unquestionably stems from the realization that, though with heroic measures the statistical chances for his bare survival would be increased, the city with which his life is identified would inevitably be a charred and dismal waste after an attack. It would be hard to persuade him otherwise.

So far as the protection of industry is concerned, a program to accomplish it through a combination of hardening and dispersion would have to start on a highly selective basis, and would almost certainly begin with industries manufacturing key military items. The first question that would arise is: What are the key items in this vastly new kind of war? Further, at each point there would be the question whether it would

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not be better as well as cheaper to store the relevant finished commodities in dispersed shelters.

The protection of one's retaliatory air arm is another matter. SAC constitutes a relatively small segment of the national community in terms both of the manpower and the materials it comprises. It has a special capability for defending itself in that its major implements, aircraft, can take to the air on very short notice. However, after a defensive takeoff, they would normally have to land to take on fuel and bombs before departing on their retaliatory mission, and sufficient facilities for these operations would also have to survive any surprise attack. The temptation to combine an escape fly-away plan with direct retaliation against the enemy tends to be stymied by the fact that it takes a good deal longer to get off an organized strike against enemy targets than it does merely to get the same number of planes into the air for the purpose of getting them out of harm's way.

In general, the strategic air arm must resort to some combination of dispersion, hardening of facilities, and provision of reserve strength. Just what the combination of measures should be has been a subject of intensive research.¹⁵

¹⁵ By a RAND project team under the leadership of Albert J. Wohlstetter.

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In this connection we must recall the observations made at the beginning of this chapter about the common military bias against "defense-mindedness." The Navy learned the hard way during World War II that while it was all very well to refuse to sacrifice offensive for defensive armament, a warship had to remain afloat in order to have any offensive capability at all. No doubt the applicability of this lesson to our Strategic Air Command is clear to all. Certainly the learning cannot be left to the first year of another war.

There can be no rule of thumb to determine what it is worth spending to secure the protection of SAC. Our SAC deserves an absolute priority charge upon the defense budget, and to provide for its security is as important as to provide for its existence. But perhaps some rough guides may help determine whether or not the matter is being pursued seriously at any particular time. One elementary test, certainly, must be an absence of arguments to the effect that the security of SAC resides in its taking the initiative at the moment of crisis. Such a presumption or hope is a weak reed for the military to lean on in a country such as ours, where they cannot control the decision for peace or war and should not wish to. It is also true that one of the glittering strategic prizes to be gained in making SAC reasonably secure is the freedom accorded

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our leaders to decide whether or not they are going to use that force at any particular level of crisis. An insecure SAC would oblige them to be trigger-happy; or, if they were capable of realizing the danger, would prevent them from facing up to a crisis.

Summary

From the facts reviewed above it is possible to make some tentative but important **deductions** about the possibilities of defense against strategic nuclear attack. First, the number of human casualties would probably be closely related to the extent and the wisdom of precautions taken before the event. On the other hand, so long as large masses of our citizens are gathered in metropolitan centers, the minimum figure of fatalities to expect in a surprise enemy attack must inevitably be reckoned in scores of millions. The figure will vary with the degree of surprise actually achieved by the attacker, but it is hard to conceive of circumstances that would permit it to fall to a **figure** as low, say, as ten million. Much will depend on how anxious the attacker is to destroy human life, as distinct from simply rendering the target state militarily impotent. The past trend in weapons, with their ever-larger yields and greater potentialities for fallout, has certainly

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increased the capability for human destruction of the aggressor who wishes to accomplish it.

The larger cities themselves, that is, the buildings and other physical equipment of urban life, and the industrial production associated therewith, are irretrievably at risk. One cannot conceive of passive defenses that will protect urban dwellings or factories, and active defenses of the kind we know today and expect to see in existence in the reasonably near future can at best reduce the total number of targets struck. Such reduction offers little hope of protecting those important cities that the enemy may most want to hit.

The old adage that every new offensive development inevitably provokes the development of a suitable defense has been exposed as excessively optimistic by the existing new weapons, and one should hesitate especially to apply it to the long-range ballistic missile of the future. That is not to say that effective active defenses against the missile are technically impossible, or that their development should not be pursued; it is only to point out that it requires extraordinary faith in technology, or a despair of alternatives, to make one face up to depending on them. In so far as such defenses require reliance on a completely automatic response (it is hard to see, with the very short flight times involved, how a defense system

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that detects an enemy missile on the way can afford to permit human judgment and decision to intervene), the relevant problems are as much political and social as technological. A system with enough built-in sensitivity to react promptly to any real attack must be sensitive enough to respond to false alarms or deliberate enemy "spoofing."¹⁶

Regardless of what is done or not done to defend cities and populations, there can be no question that a very considerable defense effort, passive as well as active, deserves to be put upon our retaliatory air force. For that air force has the following characteristics: (1) it is sure to comprise the absolutely-top-priority enemy target system if there is any attack at all; (2) it is a naturally vulnerable target system in the absence of special and considerable defense provisions; and (3) it appears that its "natural" vulnerability can be critically if not decisively reduced by measures that seem to be of reasonable cost in relation not only to our entire defense budget but even to the cost of the strategic air arm itself. And if ~~we~~ be permitted, because of its importance, to make the observation once again, an obviously vulnerable SAC does not

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If an opponent wants to, he can probably shoot missiles at us (to trip off our countermeasures) secure in the knowledge that none of them will hit the ground. For, unless specific provision is made against it, long-range missiles will tend to burn themselves out upon re-entering the atmosphere in the final stages of flight.

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merely fail to be a deterrent against attack; it positively invites it.

To the extent that reliance is put upon passive rather than active measures (i.e., hardening of base facilities and sheltering of bombers), the vulnerability of the retaliatory force would not appear to be sensitive to the attacker's shifting from manned bombers to ballistic missiles. Whether long-range missiles within the retaliatory force would be more or less vulnerable to enemy air attack than bombers remains to be seen from the form they eventually take. However, it is clear that, in the air, a ballistic missile is bound to be less vulnerable than a manned aircraft, and that a surviving rump of a missile force would therefore be more certain to reach its targets than the surviving rump of a bomber force.

The tentative conclusions ventured above have been inhibited far more by the lack of directly relevant research, particularly with respect to passive defenses, than by other considerations. However, while more research on defense measures of all kinds is much to be desired, it seems apparent that the injury received by an attacked state from nuclear strategic bombing must involve some colossally high minimums. Also, it is clear that, while some tractable portions of the defense problem are lamentably neglected by researchers, other

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portions involve important conceptual questions for which we cannot hope to get good answers regardless of how much research is done. For these reasons, the strictly technological results of existing and future research on defense measures must be treated with caution and flexibility in making relevant deductions for national policy.

One other point. We frequently see in the public press estimates of damage resulting from a hypothetical enemy attack. These estimates usually assume, explicitly or implicitly, fewer and usually smaller weapons than we have any right to expect the enemy would use, especially if he had the initiative in making the attack. The same is true of such "Operations Alert" as those of June 15-16, 1955, and July 20, 1956.

Some of the justifications given for the relative modesty of the assumptions are entirely reasonable, provided the authorities keep in mind what they have done and why. We should, however, be clear that in view of our own strength now and in the future, any potential adversary would be mad to launch an attack on us unless his capabilities were enormously greater than those estimates mentioned above usually imply. One can conceive of an initial strike upon us being kept small in order to exploit surprise in getting at our SAC, but such a strike would almost certainly be an immediate prelude to a

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much larger one, especially since the enemy could never plan with assurance on destroying our SAC with his first blow. The only kind of strategic air attack we have to fear is a gigantic one.

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