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DEFENDING A STRATEGIC FORCE AFTER 1960

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With Notes on the Need by Both Sides for Accurate Bomb Delivery Particularly for the Big Bombs

Summary

A. This paper presents tentative findings of a first (and somewhat primitive) look taken some four or five months ago at the defense of SAC against the Intercontinental Ballistic Missile. It needs, and is now receiving, elaboration and further testing.

B. The defenses programmed, or recommended, to protect SAC in the Fifties will be entirely ineffective against an IBM which would deliver bombs with essentially no warning. It now appears this weapon may be feasible for the Russians by the end of this period.

C. Several methods of protecting SAC against the IBM are illustrated in this document along with evidence indicating that they will assure the survival of a large proportion of the strategic force in the face of this threat. They are also shown to cost very much less than leaving SAC unprotected against this threat, provided the threat is a real one. The proposed defenses rely principally on sheltering to exploit the limitations in accuracy and payload of the missile.

D. This type of defense works for the protection both of manned bombers and of ballistic missiles on the ground. However, in both cases it offers clear protection only against the ballistic missiles or other weapons with analogous limitations in accuracy and payload.

E. The method, it appears, may not suffice against manned bombers with lower CEP's and higher payloads. In fact, the Strategic Airbase

Study rejected this type of measure as a defense for SAC in the Fifties. In the Sixties, even if we must buy this kind of defense, in any case, against the ballistic missile, it will not be an optimal defense against other threats: it appears it will need supplementing against threats with distincly different performance characteristics.

F. This fact has implications for the offense as well as the defense. It suggests a mixed system for each. The offense could well include in its mixture some high-accuracy high-yield delivery systems for use against hard targets, perhaps the bulk in number of its target system. And the defense had best be prepared to defend itself both against a warningless and inaccurate bomb delivery, and against an attack with warning with weapons of extremely high yield, delivered with considerable accuracy.

G. The measures illustrated are not proposed as optimal. (For one thing there are gaps in our knowledge of the loading and behavior of structure of extreme resistance and these are gaps which the analysis indicate are well worth closing.) However, they are shown to be adequate and, for a fixed budget, better than non-protection. One component study for the project, "Strategic and Counter-Strategic Systems after 1960," will consist in a more detailed analysis of better methods of protecting SAC against the IBM.

H. Finally, the methods used are not appropriate to the defense of entire cities where a large CEP cannot, it appears, be exploited economically. So this important problem, now being examined under the leadership of W. B. Graham, is an open field.

I. None of the limitations of the IBM suggested here together with the possibilities of defending SAC against it imply that the development of the IBM should be delayed or is less desirable in any way. This weapon would be handy to have around, in spite of its possible ineffectiveness against BRAVO targets.

1. The Critical Importance of Assuring the Survival of SAC

Whether or not we achieve the defense of our cities and industry against the intercontinental ballistic missile, it is critically important to assure SAC's survival against this or any other likely threat. If the IBM is a probable threat, and we cannot protect our strategic force against it, then our advertised capability for retaliation will be fictitious. We could not expect to hurt the Russians very much, unless we could be sure to strike the first blows. This should make us rather trigger happy, particularly if we were to couple this fragile strategic capability with an announced policy of relying mainly on a threat of major strategic atomic attack to deter even minor war. It would appear also to make the Russians equally trigger happy. Because in this case striking the first blow is the only means of defense, any delay in striking the first blow by either side risks the chance that the enemy will be the one to have this prerogative. With a defense of SAC against the IBM and any other likely menace, on the other hand, we can assure ourselves and Russia that whether we strike first or second we can lay waste a large proportion of the Russian economy and the Russian population. This will make a decision to strike a first blow extremely unpleasant for the decision-maker as well as for the recipient of the blow.

In this way, of course, it constitutes a kind of protection for our cities. It has been suggested, in view of the slimness of the chance of intercepting the missile once launched, that killing it on the ground before launching or just after launching is a more inviting avenue of defense. An invulnerable SAC might affect the decision to launch the missiles against our cities. In this way defending SAC is equivalent to an attack on the stage just before the launching.

It perhaps is worth mentioning that emphasis on the deterrent character of our retaliatory power, while currently very much in the headlines, is not confined to the present political administration. It is an essential part of the present government program, but it was also quite as essential in the time of Mr. Truman and Mr. Acheson. It has had official prominence at least since the Finletter report and the report of the Brewster committee in 1948. Moreover, whether or not we can rely on an assured capability for atomic retaliation to deter even peripheral wars (which is subject to doubt), such a capability does have, it appears to us, a vital importance. This importance can be seen most persuasively perhaps if one faces the problem of preserving this retaliatory power. Then it is clear not only that an invulnerable SAC is a deterrent but also that a vulnerable SAC is an urgent invitation.

2. Inadequacy of the Fifties Defenses against IBM

We may conclude from the preceding that unless the Russians are desperate or bungling, they will attack if and only if — and particularly only if — they can have a high confidence of eliminating the major part of SAC. Unfortunately, even given the execution of present Air Force plans for SAC defense and all RAND recommendations for such defense, a rather modest total of intercontinental ballistic missiles of the RAND type will put the Russians in this position.

Neither the various known alternatives for active defense nor the measures of evacuation which were found to be a major component in the defense of SAC against the sorts of attack anticipated in the 1950's suffice against IBM. All of these actions require a considerable amount of warning. The terminal 2 1/2 to 3 minutes warning, which improved radars placed in the general target zone might provide, would barely permit even prayer. The missiles may be expected to suffer a negligible amount of attrition by our projected active defense, and on arrival at the bases in an opening attack they would find these bases quite fully occupied by our bombers. We have performed several tests of the expected damage at appropriate ranges to our bombers by missiles with the payloads and error characteristics involved in recent proposed designs. (We used random bomb drops with an elliptical Gaussian bi-variate distribution.) For the most distant bases, between three and four missiles per base sufficed for achieving an expectation of over 80 per cent destruction; for the closer targets 2 bombs per base had an expectation of about 90 per cent. (At a range of 5,500 n.mi. the missile is assumed to have an equivalent CEP of 3 n.mi. and a warhead of .5 MT yield; at a range of 4,000 n.mi. the equivalent CEP falls to 2.15 n.mi. and the warhead rises to 2 MT yield.) Given these results and the expected reliability stated in recent missile proposals, it is not very difficult to calculate the expected damage to SAC as a whole. Take a force of missiles requiring an amount of fissile material well within the expected number in the Russian stockpile by 1960, as estimated by Air Intelligence. If we assume launching sites in plausibly selected regions,* the Russians can destroy over 80 per cent of our strategic bombers with a confidence of 95 or better, and they can do this with a force of missiles of the order of 150.

*These areas have been suggested by Hans Heymann, J. DeHaven and R. L. Stewart as plausibly appropriate locations for Russian missile bases, considering logistics, defense, climatological matters, etc.

Even with the high crit requirements of these missile warheads this force would consume less than a third of the expected Russian bomb stockpile in 1960 according to the Air Intelligence estimate of the stockpile — an amount which is, in fact, smaller than the expected increase in the stockpile between 1960 and 1961. Availability of fissile material, then, would be no problem even at the start of this period. (And neither, it seems, would there be a general resource constraint.) While these missiles are not cheap the expected cost of such a campaign for the Russians appears quite moderate considering the value received. This is true even if all 150 missiles were fired in salvo so as to assure arrival without warning. The 150 launchers involved in such a simultaneous attack are a little less than double the number contemplated by RAND in its current IBM costing. In fact it appears clear that the Russians might be expected to achieve even higher levels of destruction, given their anticipated capability and assuming no move on the part of SAC to meet this problem.

3. Principles of the Defense

The central idea of the defense methods proposed is to exploit the characteristic limitations of the IBM. These are its restricted accuracy and its limited though rather large (on our rapidly obsolescing standards), payload. They are, in short, the major performance characteristics which, it has been perceived, have to be weakened to make it a feasible weapon in our time. The weakening of performance here was suggested by a consideration of city targets which are large and soft. Bases, however, can be made extremely hard.

The strategic airbase study tested an extensive list of what it designated "microscopic passive defenses" — that is, passive defense measures such as dispersal within a base, blast protection, etc. — which were local to the individual bases. These were contrasted with such "macroscopic defenses" as multiplication of bases, the separation of bases by great distances from enemy territory, etc., which qualify the base system as a whole. Microscopic defenses consider the base system in the small and macroscopic defenses consider it in the large. Both microscopic and macroscopic passive defense measures were found to be inadequate protection against attack by manned bombers. Given CEP's of reasonable magnitude we found the microscopic defenses in particular very sensitive to bomb size. However, given CEP's on the order of 2-3 miles, the situation is something else again, even with a bang as large as 500 KT or 2 MT or more. The macroscopic dispersal of operating bases was found to be very sensitive to bomb number and it would appear to be so when we are considering defense against the IBM. But against the IBM, the microscopic passive defense measures escape the simple matching of additional bases against additional bombs. Given large CEP's with a limited bang they force a disproportionate increase in the enemy bomb requirement.

They accomplish this first of all by massive blast protection which drastically reduces the lethal radius — in effect making these very large bombs quite small. And second, with the big bombs cut to size, they can exploit various forms of microscopic dispersal. (While it is shelter which yields non-linear benefits, both macroscopic and microscopic dispersal are likely components of an optimal defense.) And finally these changes in the disposition and sheltering of planes and of personnel are associated with methods of operation calculated (a) to take advantage of any warning received, (b) to provide insurance in case no warning at all is received, and (c) to reduce the delay times imposed by radiological contamination.

4. Illustrative Microscopic Passive Defense Measures

In this first rough cut we have considered a collection of measures, some involving dispersal without shelter, some involving shelter without dispersal, and several which involve a combination of shelter and various sorts of dispersal. We have tested shelters of two degrees of hardness. We have not attempted to choose optimal degrees of blast resistance, optimal forms and distances of dispersal, or optimal proportions of the force to be protected. These problems are reserved for the next try.

The Shelters and Their Cost.

Two kinds of underground shelters were considered, involving two distinct levels of bomb resistance. The first, modeled on a Joint Air Defense Board design* for bombing aircraft, will resist 55 psi. Its cost: roughly 567,000 dollars. The second shelter is specified only with respect to its bomb resistance. It is to be vulnerable only to coverage by the crater or crater lip of a surface or penetration burst bomb. Nothing definite is known at present of the cost or feasibility of such an extreme shelter. It has been included here to estimate the payoff to such a shelter.

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*This particular Joint Air Defense Board shelter is quite ingenious. It avoids the large clear span of the usual above-ground aircraft hangar by sinking the plane on a hydraulic elevator into a cruciformed pit which follows the outline of the plane itself. Sliding, massive concrete doors level with the ground move horizontally across the small spans involved in this pit.

The Types of Dispersal.

Dispersal against the intercontinental ballistic missile might well exploit the elliptical character of its error distribution. Range errors at 5500 nautical miles will be three times those in azimuth. And at the ranges involved the major axis of the ellipse would be essentially north and south. Linear dispersal normal to this axis is an attractive possibility. In our tests we considered in addition to the basic undispersed cases only two types of dispersal. One was a dispersal normal to the major axis of the ellipse in two clusters of planes. The other was a kind of area dispersal in a half-dozen clusters.

The Results.

The results in brief were (1) microscopic dispersal without shelter, as might be anticipated, given the large lethal radii, did not substantially reduce the vulnerability of the basic, unsheltered, undispersed case. The expected number of aircraft on a single base destroyed by a given number of missiles declined at best by about a third. And this, as the missile requirement calculated for the basic case suggests, is hardly a significant gain. (2) The moderately sheltered case (55 psi) showed a very distinct improvement, cutting the expected damage by one bomb in the basic case by a factor of about 7. (3) The joint use of moderate shelter and dispersal improved matters further, halving the vulnerability again in the two-clustered dispersal. But the most drastic reduction was contributed by the further toughening of the shelters.

*In line with several previous RAND studies the enemy found it best, given the large CEP's, to use one DGZ in spite of the considerable separation of the targets.

(4) The toughest of the cases tried involved aircraft with the tough shelters dispersed into two clusters. This reduced the vulnerability of the basic case by a factor of about 200. The expected number damaged by a single 2 MT bomb with a 2.15 mile CEP came to .24 out of 65 aircraft.

A defense posture including the use of the 55 psi shelter and 2-cluster dispersal has been compared with a situation where the bombers are unsheltered and undispersed in a fixed budget analysis for the Medium Bomber portion of SAC. It has been assumed that defenses against the ballistic missile may be purchased at the sacrifice of an equal dollar value in bombers and their associated systems. Both types of shelter defense incur annual costs which are quite low relative to the initial investments in them, markedly lower than in the case of the bombers which are sacrificed for them in this analysis. It follows that the comparison is sensitive to the length of the period assumed for costing. An increase in the length of the period considered, improves the showing of both shelters relative to the undefended case, and improves the tougher shelter relative to the 55 psi shelter. To demonstrate this effect, the comparison is made in terms of both three year costs and ten year costs. The results, in terms of number of bombers surviving two levels of missile attack, are shown in Fig. 1.* This figure makes clear the extreme vulnerability of a bomber force without defenses against IBM. It also indicates that the value of the bombers saved by the moderately hard shelter is far in excess of the cost of the shelters even for a low

*This figure is based on the simplifying assumptions that bombers are deployed one wing to a base and that all bombers are within shelters at the time of bomb impact. Both assumptions are being reviewed in current work.

THE EFFECT OF MICROSCOPIC PASSIVE DEFENSE FOR 2 LEVELS OF IBM ATTACK

(Three-Year Budget of $18.0 Billion)
(Ten-Year Budget of $41.0 Billion)

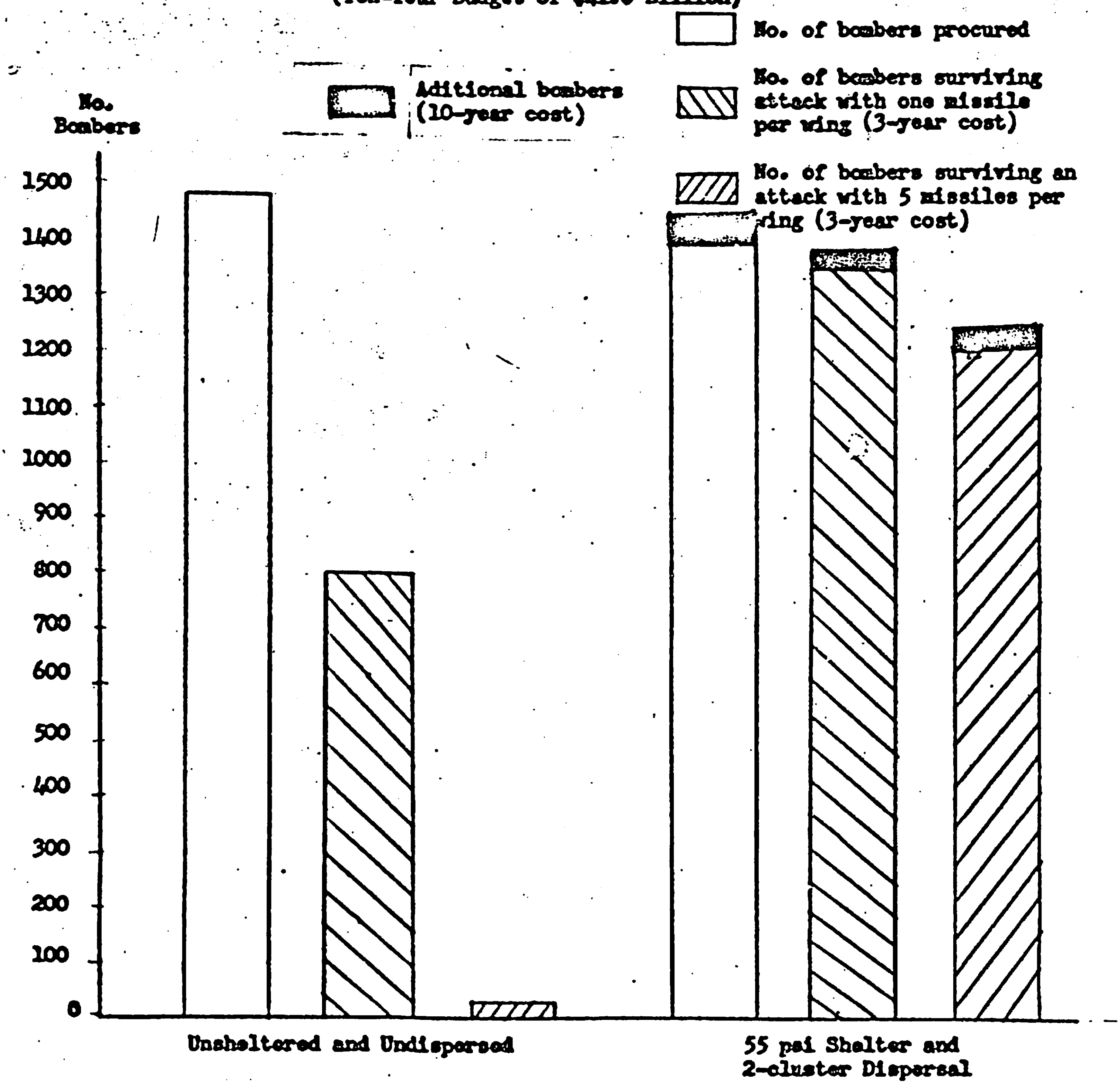

FIGURE 1

level of IBM attack, and regardless of the length of the time period chosen for costing.

The extremely tough shelter has not been included in the comparison of Fig. 1 for lack of cost data. However, we can obtain a rough idea of its worth as an alternative to the 55 psi shelter, by a break even analysis. Table 1 shows the results of such an analysis. If the cost of the tough shelter were equal to the amount shown in the table for some given situation, it would, for a fixed budget, provide the same number of surviving bombers as the 55 psi shelter. At a lower cost, it would be a preferable defense — at a higher cost it would be a worse defense. It is evident from these break even costs, that the benefits from such tough shelters are sufficiently high to make worthwhile the study of the feasibility and cost of structures in this little understood range.

To get a rough idea of the adequacy of the shelters, we have tested their performance under attack by a force of Russian IBM's whose size was determined by assuming a Russian budget for this purpose equal to the three year cost of the U.S. SAC medium bomber force. The missile costs used are preliminary Cost Section estimates of the U.S. cost of the IBM. The Russian IBM salvo capability which was obtained from this process amounts to roughly 300 missiles. If the first salvo* were completely free from aborts and devoted entirely to single-wing SAC medium bomber bases protected by the 55 psi shelters, the expected destruction would amount to 30 per cent of the force. The same salvo directed against bases defended by the tough shelters would yield expected destruction amounting to about 2 per cent of the force.

*See Section 5 below for reflections on the relevance of subsequent firings against SAC.

Table 1

BREAK EVEN COSTS FOR TOUGH SHELTERS

(As Alternatives to 55 psi Shelters)

	Three Year Cost	Ten Year Cost
Bases at 5,500 n. mi.		
1 IBM per Wing	.7	.8
5 IBM per Wing	1.2	1.9
10 IBM per Wing	1.5	2.5
Bases at 4,000 n. mi.		
1 IBM per Wing	1.0	1.4
5 IBM per Wing	3.1	6.1
10 IBM per Wing	7.7	15.9

The defense, it should be observed, appears to work for a missile base as well as an aircraft base. We have made a preliminary test on the passive defense of a missile installation, and the results of this test confirms this fact.

The factors determining the results may be suggested heuristically by the following. The lethal radius of a 500 KT bomb against a bomber is some 17,400 feet, neglecting drag effects which will bring this up. Even with so large a CEP as three nautical miles, then, the ratio of lethal radius to CEP is unity and the familiar point coverage formula* yields a probability of roughly .5 for the destruction of a point target. The point coverage suggests the outcome of an area coverage experiment. Given some 65 adjacent "points," that is, tankers and bombers, on a one-wing base, the expectation of a small number of 500 KT bombs with three-mile CEP could be surmised to be quite high. And as the random bomb drops whose results were summarized in section (2) indicate, the expectation __is__ high. The missiles launched at shorter range with larger bomb yields have even greater expectations.

The 55 psi shelter cuts the lethal radius of a 500 KT bomb by a factor of nearly 5, bringing this to about 3600 feet, which is about the lethal radius of a 10 KT bomb against an unsheltered plane. The tougher shelter cuts the lethal radius by a further factor of about 6, bringing it to about 600 feet (The above would be emphasized even further if we consider the drag effects. The unsheltered plane above ground is

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* $1 - 1/2^{\left(\frac{LR}{CEP}\right)^2}$

a drag target. These underground shelters are not.) The effect on the squared term in the point coverage formula $\left(\frac{LR}{CEP}\right)^2_{1-1/2}$ and on the coverage value itself is of course more marked, with the result that even for the larger warhead missiles operating from close in, the point coverage is very small against planes with the moderately tough shelters and essentially zero against planes with the very tough shelters.

5. Evacuation, Salvos, and Radiation

In concentration on the few minutes of terminal warning which we shall have at the very most for the first surprise attack, we may forget that the second launching from any given launcher will take a considerable amount of time. It seems possible, then, to avoid the cumulation of expected damage from several missiles, unless they are all fired in salvo. There is no necessity for remaining on base after the first salvo in order to wait for the second. Some hours later radiation will have decayed to permit bombers and crews equipped with protective clothing to take off singly.* The decay is fast and the period of exposure will be short. This tactic would impose a heavy requirement on the enemy in missile launchers and would compound the drain on his resources.

The problem of continuing effects of radiation might be met in a similar way. While the home bases may for a very long period be impossible to use continuously, they could be used for staging purposes in a matter of days. This order of time delay in SAC campaigns would hardly warrant the huge costs to the enemy.

*Even for a very high level of residual radiation (5000 roentgens/hr. at one hour) exposure for a 15 minute period at the end of 8 hours would result in a total dose of 100 roentgens.

Shortening the cool-off period by limiting base occupancy to staging was one of the recommended defenses in the period of the Fifties, not only for overseas bases but for contaminated home bases.* During the Fifties the problem of avoiding the <u>initial</u> high-dosage rates could be accomplished in the ZI by improvements in the evacuation plans. What of the Sixties?

6. Warning, Radiation, and the Disposition of Our Forces

There are three states of warning we might consider: One in which the bases with improved radars in the vicinity obtained some two and a half to three minutes warning for all missiles delivered; the second with no warning whatsoever, and a third in which several salvos are fired with little or no warning for the first but with a day or more for the second. If we have any warning at all — either through improved radars or through early arrival of missiles at some of the bases — personnel may be able to dive for shelters and these can be equipped with radioactive filters, etc. If we cannot hope for even this, then SAC would have to adopt a method of operation which would assure that there will be no time at which the entire force is exposed. Something of this is implied in any case for the bombers, even if there are to be a few minutes of warning. If there is to be no warning, then a four-shift arrangement for the crews is indicated, with the crews living off base. A microscopic passive defense for a portion of the force at all times is both feasible and necessary.

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*See A. Wohlstetter, F.S. Hoffman, R.J. Lutz, and H. Rowen, "Selection and Use of Strategic Airbases," The RAND Corporation, Report R-266, TS-972, April 2, 1954. (TOP SECRET)

7. Vulnerabilities to Attack by Manned Bombers

If we have to buy such a defense in any case to protect ourselves against the ballistic missile threat, will it serve against all other likely threats? This seems doubtful. These defenses depend essentially on the large CEP's involved in the missile. An accurately delivered large-yield weapon would destroy any of the microscopic passive defenses we have tried so far. Take a case which is certainly not to be excluded: a 25 MT surface burst bomb, with an 1800 foot lethal radius and a CEP of 1500 feet attained perhaps in a daylight attack by heavy bombers manned with select crews. Our bases can be located with precision by the Russians and lower CEP's than this might be attained if it is important to do so. One such bomb has an expectation of destroying thirty three of the 65 planes on our toughest base. The squared ratio of lethal radius to CEP in the point coverage formula works here to the advantage of the offense. It doesn't seem feasible to make crater-resistant shelters and so reduce lethal radii any further. The possibilities of gains in defense through microscopic dispersal are limited by the large ratio of the cratered area to the total base area. The microscopic passive defense measures considered so far at any rate need supplementing if the enemy is not to destroy our force with a moderate force of his own. And it appears unlikely that such very different threats can best be met by a single defense. This suggests not only a mixed offense for the enemy and a mixed defense for us, but that we will find a mixed offensive force optimal with broadly different components appropriate to broad differences in target.

8. Why the Big H-bombs in Particular Need Greater Accuracies

In early assessment of thermonuclear weapons it was clear that one of their obvious implications, particularly when taken in conjunction with the steady expansion in our fissile material stockpile, was a relaxation in the accuracy requirements to bomb the traditional SAC target system. At the same time it was clear that with these weapons in our expanding arsenal, even with high CEP's, we might make short shrift of anything worth bombing in the strategic target system — that is the Delta system — and, therefore, that we might be able to turn our attention to such worthy objects as counter-force targets, which become increasingly worthy as the Russian stockpile increases. But, on examination, it now appears that these counter-force targets can be made hard enough to require both large yield weapons and low CEP's, and their defense may, in fact, be forced by ballistic missile developments precisely in this direction. And, since worthwhile counter-force targets appear much more numerous than worthy disruption targets (both population and industry are clustered at a relatively few points), it appears that low CEP's and large-yield weapons may make up the bulk of our delivery requirements. In this way, the immediate implications of the H-bomb for relaxing accuracy requirements in the case of Delta targets which continue to be large and soft, carry in train the more remote consequence described, namely the expansion of our objectives to include a preponderance of targets with potentially opposite requisites. At the present time there are under way several studies prompted by the development of multi-megaton weapons, which have as aim the revaluation of the RD program for low CEP bombing systems. It is very important that these studies consider not only the implications of the

H-bomb for the Delta target system but also for the possibly larger tasks numerically constituted by the BRAVO and related missions.

This is not to say, that, we are certain at this time that the BRAVO mission should in fact be allocated the bulk of our strategic bombing budget. This depends not only on the desirability of this mission but also on its feasibility and cost. However, if this choice is to be open to us at all there are several sorts of research and development which must advance between now and the time the choice is to be made: developments in reconnaissance are clearly required and it appears from the foregoing so also may be developments in bombing accuracy.

9. After After 1960

The foregoing also suggests that even against the ballistic missile this defense would have a finite life. The missile might improve drastically in accuracy and payload. However the date at which the Russians will have a missile capable of carrying a 25 MT bomb with a 1500 foot CEP appears sufficiently far removed to make the defense good, let's say, until the end of the Sixties.

10. Limitations and Plans

There are clear limitations both in the basic physical data available for this analysis and in the analysis itself.

In general "lethal" effects of nuclear weapons have been explored so far largely in relation to civilian targets or to military targets which were not designed specifically to resist nuclear attack. It is true not only of blast but also of radiation and contamination effects that the magnitudes we might find feasible to resist whether by comparatively few well-defined and controlled functions than in the case of sprawling cities with numerous essential functions difficult to relocate, reorder or control. The necessity of defending our bases as well as the importance of destroying the enemy's indicates the need for an intensive program of research in this area of military structures of extreme bomb resistance.

The limitations of this first analysis are apparent. A more detailed analysis of a wider variety of cases can be programmed for the 701, and a more general study of the relations between extreme size in CEP, bomb yield, and bomb resistance is indicated. So also a more careful consideration of the costs and an analysis of the alternatives for both offense and defense — for example, strategies mixing attacks with both manned bombers and ballistic missiles and the counter-strategies — and so on. These are the next steps for this component of the study of Strategic Systems After 1960.

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