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THE PRESIDENT'S SCIENCE ADVISORY COMMITTEE
EXECUTIVE OFFICE BUILDING
WASHINGTON, D. C.

REPORT OF THE AICBM PANEL

The AICBM Panel of the President's Science Advisory Committee has had two meetings since submitting the last report dated May 21, 1959. On September 21 and 22, 1959, we met at Bell Telephone Laboratories, Whippany, New Jersey, to examine in some detail the status of the Nike-Zeus program. Following this, we met in Washington to further consider the Nike-Zeus program and, in addition, to review the overall AICBM effort. During the latter meeting we heard the following presentations:

The Role of Nike-Zeus in Defense of the Continental United States (U. S. Army)

Potential Contribution of Nike-Zeus to Defense of the United States (WSEG)

Budgetary Consideration of the Nike-Zeus Program (OSD-Air Defense)

The Advanced Research Projects Agency Ballistic Missile Defense Program (ARPA)

During the course of these two sessions, we were exposed to deployment and cost-effectiveness studies conducted by the Bell Telephone Laboratories, the Weapons Systems Evaluation Group, and by a U. S. Army Air Defense Ad Hoc Committee. On the basis of these studies, it is now possible to draw specific conclusions regarding the potential effectiveness and cost of a Nike-Zeus AICBM system for providing a defense against the ballistic missile threat.

It now seems clear that the Panel's earlier views regarding the problem of ensuring the survival of the U. S. retaliatory capability have been confirmed by these recent quantitative evaluations. The following pertinent comments are quoted directly from the AICBM Panel Report, dated May 21, 1959:

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"The Panel concluded that, in general, the tactics of dispersal, hardening, concealment through mobility, and quick reaction upon early warning are more certainly effective than active defenses for protection of the retaliatory force. These "passive" tactics are now available, can be implemented to an effective degree relatively soon and can, unless precluded by redundant operational requirements, be more inexpensively effective than active defenses. The Panel believes that these "passive" tactics should be considered as the basic anti-missile defenses for both the aircraft and missiles of the U. S. retaliatory force. We urge, in the strongest terms, that they be exploited more fully and more rapidly than called for in present plans. If defense of hard targets is the objective....(of deploying the Zeus system)... then the presently conceived (Nike-Zeus) system without hardening is of very doubtful value."

In its previous report, the Panel also commented on the possible utility of employing an active AICBM system in the defense of population centers. The following remarks, which the Panel members agree are equally applicable today, are also quoted directly from the May 21, 1959 Panel Report:

"This subject....(the value of active defenses).... was discussed with relation to the urgency that appears to attach to the Nike-Zeus program. Active defenses appear to be the only means of achieving some protection for cities against attack by missiles. Without challenging the overriding importance of protection for the retaliatory force, the Panel notes two circumstances in which protection for cities has value:

(a) The condition in which the Soviets have a superiority in missiles great enough that they can direct up to a few hundred, but not as many as a thousand, missiles at cities in addition to those directed at our retaliatory forces. In this case, active defenses would not contribute to preventing attack, but could nonetheless save many lives.

(b) A situation in which offensive forces are limited by an agreement which is politically and technically enforceable.

None of the above circumstances can be ruled out as possibilities for the future."

The fundamental question before the Panel at the present time is whether or not steps should now be taken to produce and deploy the Nike-Zeus system. The considerations involved in arriving at an intelligent answer to this question fall into two distinct categories, specifically: those which concern the technical status and estimated operational capability of the Zeus system; and those relating to the relative cost and effectiveness of Nike-Zeus if it is assumed that the system can be made to perform according to the stated design specifications.

TECHNICAL CONSIDERATIONS OF NIKE-ZEUS

Decoy Discrimination

It is apparent that, in spite of the study efforts of the past year, no adequate decoy discrimination technique has yet evovled. We therefore cannot expect the Nike-Zeus system to be capable of satisfactorily distinguishing between incoming sophisticated decoys and true warheads.

Dr. Arthur Kantrowitz, whose group has been engaged in the design of decoys for the U. S. missile program, is convinced that it is possible to make decoys that are, by any known radar technique, indistinguishable from a true nose cone above an altitude of 170,000 feet or possibly even lower. Such decoys need weigh only about 2 to 4 per cent of the weight of the actual nose cone they are designed to simulate. Less sophisticated decoys have also been proposed and many of these (of even lesser weight) may, at altitudes greater than about 170,000 feet, be indistinguishable from true nose cones by any practical decoy discrimination technique. At present it is not even clear how tank fragments (that can be employed by the hundreds at almost no cost to the attacker) can be differentiated from true nose cones at sufficiently high altitudes. It is not yet known if this discrimination could be accomplished by evaluation of the radar signatures or whether it would be necessary to continually follow many tank fragments by radar. In the latter case, even a single nose cone accompanied by a large number of tank fragments could overtax the capability of the presently planned decoy discrimination radar. (One frequently mentioned possibility would involve the explosion of a "precursor" AICBM nuclear warhead at a very high altitude. It has been estimated that many of the tank fragments might be distinguished from a heavy warhead from radar observation of their resulting, relatively large, velocity changes. Analysis of this possibility indicates that it does not appear to be a reasonable procedure. This is especially true when it is realized that the precursor burst will produce a temporary radar blackout.) On the basis of these considerations, the Panel believes that in order to achieve an acceptable

level of confidence of intercepting the dangerous objects, it would be necessary to attempt intercept of a substantial number of incoming targets. We estimate that the number of unresolved objects accompanying each incoming nose cone could range from 5 to 30. In addition to this, the system will almost certainly have to contend with a large cloud of tank fragments. Although the Panel feels that research on decoy discrimination techniques should be continued, and in fact intensified, we cannot foresee with confidence a clear-cut solution to this problem.

As a consequence, the Panel concludes that the plans for employment of any active AICBM system that achieves kill during the terminal phase, as does Nike-Zeus, must be predicated upon the need to intercept several objects in order to achieve a reasonable confidence of destroying a single incoming warhead.

System Planning

The difficulties posed by the decoy problem have prompted the Bell Telephone Laboratories' system designers to undertake a critical review of the Nike-Zeus system configuration. In addition, with the realization that inexpensive firepower offers the only available means to cope with a large number of undiscriminated objects, every effort is being made to find non-nuclear kill mechanisms that might reduce the total cost of the intercept missile. This concept, which is certainly desirable, if feasible, is based on recent miss distance estimates of about [redacted] or less at an intercept range of [redacted] (This is to be compared with previous miss distance estimates of about [redacted] at intercept ranges of [redacted] Nevertheless, it cannot be predicted at present that reliable kill by non-nuclear means will actually prove feasible. On the other hand, if one desires to make use of shorter intercept ranges (to achieve a decrease in miss distance), and if the relatively high warhead weights that might be required to accomplish non-nuclear kill can be tolerated, it would also appear possible to employ a suitable nuclear warhead that may be much less expensive than the present warhead design.

Frequency Changes

Studies conducted since the last AICBM report have disclosed that the blackout problem at [redacted] is even more serious than we had anticipated and indicates a positive need to go to higher frequencies. The Bell Telephone Laboratories have concluded, on the basis of recent analyses, that the optimum frequency for the Local Acquisition Radar is in the range [redacted]. It is currently planned to continue the [redacted] radar development through the Kwajalein test phase of the Nike-Zeus program and to phase in the higher frequency capability as it

is developed. According to latest estimates, it appears possible to achieve a capability to operate at ..... However, approximately 3 years may be required to develop the transmitter tubes to provide the necessary power at this frequency.

Hardening of the Zeus System

In light of the extreme "softness" of the previously planned Zeus installations, the system designers have attempted to harden certain of the more vulnerable components. As an example, in view of the problem of radome collapse the design of the Local Acquisition Radar antenna has been changed from a spherical to a hemispherical configuration. This results in a change of LAR overpressure limit from ..... Nevertheless, if it is to be employed in the defense of hard targets, the Nike-Zeus installation will, in its present configuration, present the softest part of the overall target. No determined effort is presently being directed toward developing a substantially hardened Zeus configuration.

DEPLOYMENT AND COST-EFFECTIVENESS CONSIDERATIONS OF THE NIKE-ZEUS SYSTEM

The Panel has examined the three deployment studies referred to in the introduction. From these studies we can draw a number of conclusions regarding the effectiveness and cost of Nike-Zeus as the system might be employed in a number of possible roles.

Protection of the Deterrent Force

All three of the studies conclude that, even if the Nike-Zeus system achieves design expectations, it would almost certainly be less expensive and more effective to deploy additional retaliatory missiles than to attempt protection of a lesser number of missiles with the Nike-Zeus AICBM system. The arguments supporting this conclusion are contained in some detail in WSEG Report No. 45. This conclusion is valid even if it is assumed that there exists an adequate decoy discrimination technique. This conclusion is based on a consideration of fixed, hardened, missile installations, and would appear even more unfavorable for Nike-Zeus if the comparison were made with mobile missiles which appear far more reliable than active defenses for ensuring the preservation of a retaliatory capability.

Protection of Population Centers

An effective active defense of cities and the civilian population would clearly be of great value. However, this is an especially complex problem

for the following reasons:

1. The area to be protected is quite large and the decoy discrimination problem is therefore made even more difficult because almost none of the incoming objects could be neglected on the grounds that it would not hit the target. Moreover, the vulnerability of a typical city requires that ICBM kill be accomplished at a rather high altitude, probably as high as 70,000 feet.

   Cost estimates made by WSEG and BTL show that it is very expensive to provide active defenses against a large attack, particularly if the attack is designed specifically to tax the capability of the active defense system. The decoy tactic and the problem of simultaneity of arrival give rise to the two most important vulnerabilities of Nike-Zeus (and of any other active defense system that can be visualized today). The only solution for the latter problem would necessitate an increase in system fire power. This, in turn, would require the deployment of additional control facilities, missile launching stands, and interceptor missiles. When the cost of an active AICBM system is computed on an exchange basis, i.e., on a basis of the dollar cost to the defender per ICBM kill versus the dollar cost to the enemy per attacking ICBM, the exchange rate comes out very unfavorably for active defense. Even in the absence of decoys, the need to provide widespread general protection and the resultant effects of simultaneity of arrival times result in an exchange cost quite favorable to the attacker. (This is not surprising when it is realized that the aggressor has the initiative and can attack targets of his own choosing, while we must defend all likely targets.)

   Under conditions that are most favorable for active defense, i. e. no decoys of any kind, optimum Zeus performance and single ICBM attacks, the exchange rate calculated by WSEG is about 2 to 1 against Nike-Zeus. If it is further estimated that the attacker can achieve a spread in arrival times having a one minute standard deviation, the resultant exchange rate is 4 to 1 against Nike-Zeus. If, in addition, it is assumed that each incoming nose cone is accompanied by only 2 undiscriminated decoys (which probably still

constitutes an assumption unduly favorable to active AICBM), the disparity is increased to 15 to 1 against Nike Zeus. While it may be argued that cost should not be the primary consideration when American lives are concerned, one must face the fact that if the exchange rate is as high at 15 to 1, the enemy can afford to outproduce us at any level of active ICBM defense that we may choose.

2. In the even of a large attack (2000 MT or more), it is not sufficient to protect the population only against blast and direct radiation effects. It is extremely important also to provide protection against fallout. An attack of 2000-6000 MT directed against remote retaliatory installations (or merely impacted in the countryside outside the range of a limited-area active defense system) would, in the absence of fallout shelters, make casualties of a very large fraction of our population. WSEG Report No. 45 concludes that, without fallout shelters, 75% of the population would be killed by a typical fallout attack involving a total fission yield equivalent of 2000 MT. Fallout shelters alone would reduce the expected casualties to less than one-half this number. Clearly it would not be wise to deploy Nike-Zeus for protection of the population unless a fallout shelter program were also undertaken. Nike-Zeus might protect the physical property, i.e., factories, homes and the overall industrial base, (and possibly an argument can be made for the desirability of doing this to permit national recovery after an attack), however, it is difficult to rationalize the value of Nike-Zeus in terms of benefit to the present generation unless fallout shelters are provided to ensure their survival.

3. A Nike-Zeus deployment planned to cope with a substantial attack (up to several hundred missiles) might provide reasonable assurance of effectively dealing with a small attack of the kind that could result from the frequently discussed "push button accident" or from "mischief making" by a small nation that may one day achieve a missile and nuclear warhead capability. Whether or not it is advisable to invest the 2-3 billion dollars necessary to provide insurance against such eventualities is a matter of national policy that transcends technical and military considerations.

It is worth noting, however, that the existence of an active ballistic missile defense capability would greatly ease the requirements placed on a search and inspection system that would be required to monitor a missile ban or limitation agreement. On the other hand, it should be realized that the existence of active defenses might also act to disturb the balance of small stable deterrent forces.

Possible Influence on Enemy Planning

One argument employed in favor of deploying an active anti-missile defense system is based upon the resulting uncertainty that would be introduced into an enemy's planning. This argument does not appear to the Panel to be adequate to justify the rapid production and deployment of the Nike-Zeus system. However, the Panel feels that a specific study should be undertaken to compare the cost required to establish a limited active AICBM capability with the complications its existence might introduce into an attacker's plans, e.g., decoys, steeper trajectories, etc.

NIKE-ZEUS RESEARCH AND DEVELOPMENT

The Panel believes it is unrealistic to imagine that any anti-ICBM system that could effectively face the developing threat can be made operational within the next 6 or 7 years. Nonetheless, the Panel urges that research and development for the present Nike-Zeus system be continued and that a vigorous parallel R&D effort be initiated promptly to achieve: (a) a higher frequency capability for the acquisition radars, (b) an effective means for system hardening, and (c) an effective system capability in the presence of advanced confusion techniques.

The Panel is convinced that, in order to maintain competence in the field and to advance the present state-of-the-art, the United States must pursue a vigorous AICBM research and test program. The Nike-Zeus system is founded on sound technological concepts, and the Panel has a high regard for the competence of the technical staff developing the Nike-Zeus equipment. This group has, however, been long committed to meeting a production deadline. We urge that the Bell Telephone Laboratories be imaginative in their AICBM research program and that the Kwajalein test operation be conducted as a field experiment for AICBM research and not as an operational check out of a developmental Nike-Zeus system.

ARPA BALLISTIC MISSILE DEFENSE PROGRAM

Representatives of the Advanced Research Projects Agency briefly reviewed a portion of this agency's effort in the field of ballistic missile defense research and development. Much of the ARPA work in this area has involved the support of general exploratory and applied research and the compilation of applicable data and information. A sizeable effort has also been devoted to the study of possible systems that could utilize major state-of-the-art technological advances, to the development of possible system components and to planning for future demonstrations of advanced system feasibility.

We were exposed to, among other things, the concept of an advanced earth-based ballistic missile defense system that would accomplish ICBM kill by an intense [redacted] In addition, we were advised of conceptual studies underway to investigate the feasibility of a [redacted] The Panel clearly appreciates the need for continued attempts to advance our technical capability for defense against ballistic missiles. However, our general feeling is that more effort should be devoted to a fundamental understanding of the basic phenomena that offer promise for future application in the AICBM field and that less emphasis should be placed on overall concept and system design. There is a real need for de-emphasis (at least in the early study stages) of "blue-sky" proposals [redacted] before the feasibility of the concept is well established.

The Missile Range Measurements Program constitutes a substantial portion of the ARPA effort in this field. This includes, among other things, the observation (by optical and radar techniques) of various phenomena that occur during the launch, midcourse and re-entry phases of missiles fired in the U. S. ballistic missile test program. While we were unable to examine the various aspects of this program in detail, it appears to offer promise of providing some extremely valuable data. We were further advised of ARPA plans for a sizeable range measurements installation in the vicinity of the Nike-Zeus test facility at Kwajalein. Items of equipment already under procurement for this installation include the TRADEX radar (a modified version of the BMEWS tracking radar), and the PINCUSHION radar (a new radar design employing a 60 foot diameter antenna). While we were unable to determine the extent of coordination to

be effected with the Nike-Zeus test installation at Kwajalein, it appears highly desirable that there be a close planning and working relationship to avoid unnecessary duplication of effort. Because of the extremely high cost (both in dollars and in technical manpower) of missile launchings, we cannot overemphasize the need for close coordination between USAF missile firings and the test requirements of the Zeus and ARPA range measurements programs.

SUMMARY CONCLUSIONS AND RECOMMENDATIONS

(1) Plans for the design of many components of the Zeus system are still quite fluid, e.g., changes in frequency, in DDR and TTR design, etc.

(2) Further study has disclosed that the blackout problem at [redacted] is even more serious than we had anticipated and indicates a positive need to go to higher frequencies.

(3) With respect to the decoy discrimination problem, essentially no progress has been made since we last considered this subject in April 1959. [redacted] We must then reasonably assume that each Soviet ICBM may present from 5 to 30 indistinguishable, threatening objects to confuse and saturate U. S. defenses.

(4) At the present time it appears that the only way to cope with the decoy problem is to obtain sufficient firepower to permit the interception of every undiscriminated target. The nuclear warhead costs are so high that this has resulted in a requirement to utilize a much cheaper kill mechanism. The pellet warhead appears interesting although there are still many uncertainties regarding the feasibility of this concept. If it appears desirable to accomplish ICBM kill at shorter ranges (making use of the resulting smaller miss distances) by employing a relatively heavy non-nuclear warhead, it may also be worthwhile to consider the feasibility of utilizing a heavier, more economical, nuclear warhead design.

(5) As the Zeus philosophy is now developing, i.e., involving the use of "junior" radars, pellet warheads and shorter intercept ranges, it appears that the area defended by each Zeus installation may shrink to a much smaller size than previously estimated. Thus, the defense of cities or of other large areas may require a larger number of installations than previously planned.

(6) The case for obtaining any decisive contribution to our deterrent posture by the use of Nike-Zeus for defense of the retaliatory force has been disproved by studies conducted by both the Bell Telephone Laboratories and by the Weapons System Evaluation Group. This conclusion results from a straightforward comparision of the deterrent effect of a Zeus system that performs according to design specifications with the deterrence that can be achieved by utilizing additional fixed ICBM installations of the Minuteman type, properly deployed. In the event the United States can achieve mobility in missiles of this type, the case for Nike-Zeus would appear even less attractive.

(7) Although it is stated by the system contractors and by the Army study that the primary role of Zeus is in the defense of urban population centers, it has not been proved that the system can economically and effectively function in this role. Even if we could assume the existence of an effective Zeus city defense system, an obvious tactic for the enemy to employ would be the detonation of nuclear bursts outside the range of the Zeus defenses and reliance on the damaging effects of fallout. In this regard, it would be difficult to justify the installation of a Zeus AICBM city defense unless other passive defense measures had already been taken. The problem of the protection of cities must certainly be examined in a much broader context than merely that of active defense.

(8) Nike-Zeus can probably provide protection against small attacks of an accidental or mischievous nature. Its existence would also ease the inspection problem if missile limitation agreements were to come into being.

(9) At the present time it appears that there is insufficient evidence that the presently conceived Zeus system can operate effectively against advanced forms of offensive ICBM's used in a major attack, and employing tactics of confusion and decoy, to justify the initiation of a large-scale hardware development program. Nevertheless, we feel that the Zeus research program should be continued and that every effort should be made to get an experimental system into operation at the earliest possible date in order to gather data on its performance. In addition, we urge the prompt initiation of a vigorous parallel R&D effort to achieve (a) a higher frequency capability for the acquisition radar, (b) an effective means for system hardening, and (c) an effective system capability in the presence of advanced confusion techniques.

(10) A case was made last year to justify the expenditure of 137 million dollars for preparatory production in order to protect future production schedules. These funds have not yet been committed for this purpose. The recent deployment studies have led a majority of the Panel to conclude that this course is not now advisable. Some members of the Panel do believe that it would nonetheless be desirable to take practical steps to protect the production and deployment schedules.

(11) The Panel did not examine the test program and range instrumentation plans of the Nike-Zeus and ARPA in sufficient detail to be in a position to make specific recommendations, but we suspect that careful examination would show that funds could be saved by careful planning in this phase of the program. In this regard, the Panel emphasized the need for close coordination of U.S.A.F. missile firings with the Zeus and ARPA range measurements programs.

(12) It is apparent that the requirement for a discrimination capability will push technology to or beyond the present limits. To achieve this capability, one may well require the combination of several methods, each of low or medium certainty, to obtain data containing adequate control information. At the present time

there is a definite lack of adequate data on the environments of mid-course and terminal phases and on the effects of the missile and its decoys on these environments. We therefore urge that an aggressive, well-coordinated program to obtain these data be continued using current and future missile firings at every opportunity.

November 4, 1959