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THE PRESIDENT'S SCIENCE ADVISORY COMMITTEE

EXECUTIVE OFFICE BUILDING

WASHINGTON, D. C.

REPORT OF THE AICBM PANEL

May 21, 1959

The AICBM Panel of the PSAC met on December 17, 1958, and again on 25 April, 1959, to review the current state of AICBM developments, and to consider specific technical and fiscal aspects of the Nike-Zeus program.

During the course of our meetings the Panel heard technical presentations concerning:

(a) Techniques for Radar Detection and Tracking of Missiles and Satellites (Columbia University),

(b) The Nike-Zeus Program (Bell Telephone Laboratories),

(c) The Air Force ICBM Penetration Program (Air Force Ballistic Missile Division, Space Technology Laboratories, and Aeroneutronics),

(d) Decoy Design and Discrimination (Avco Research Laboratory),

(e) Anti-ICBM Target Description and Decoy Discrimination (Army Rocket Guided Missile Agency and Bendix Aviation Corporation),

(f) A Point-Defense Anti-ICBM System (Dr. Wilbur Goss of The Applied Physics Laboratory, Johns Hopkins University),

(g) Future Anti-ICBM System Concepts (Mr. W. R. Hutchins, Advanced Research Projects Agency), and

(h) U. S. Air Force Concepts of an Anti-ICBM System (Col. Gordon Gould of Air Research and Development Command).

The Panel's views concerning the principal topics of discussion are summarized below.

DECOYS AND MULTIPLE WARHEADS

This subject was discussed in an attempt to evaluate the probability that the Soviets could use lightweight warheads to permit the delivery of several warheads per missile or to permit the use of relatively heavy decoys. The Panel concludes that:

1. There is now no reason to believe that, in 1965, each Soviet ICBM will not present several, and perhaps very many, threatening objects to confuse and saturate U. S. defenses. Whether more than one of these objects is a live warhead may depend not only upon technical factors, but upon choices made by the Soviets for tactical reasons. With respect to the technical factors, it is highly unlikely that, without further nuclear testing, the Soviets will be capable of a tactic involving the use of multiple light-weight warheads (i.e., warheads yielding a few hundred kilotons in a weight of a few hundred pounds).

2. On the other hand, if nuclear testing continues, (even though limited to underground tests) there is no reason now to foresee, for the Soviets, any less sophistication

in warhead designs in 1965-66 than we foresee for ourselves. (Sophistication in warhead design does not necessarily imply the use of lightweight warheads.)

3. Soviet stocks of nuclear materials probably would not seriously limit his use of lightweight or clustered warheads until the number of such reached many thousand.

4. Intelligence cannot rule out the possibility that the Soviets will use heavy re-entry bodies (e.g., over 5,000 lbs.).

DECOY DISCRIMINATION

The defense against ICBM's with high-yield multiple warheads, employing tactics of confusion and decoy, is a problem which must be faced continuously from now on. Our own ICBM offensive plans presently include the use of much more sophisticated measures of confusion, multiple warheads and decoy than the Nike-Zeus can cope with in its present concept. We must reasonably expect that the Soviets will employ similar offensive tactics.

The recent work described by Drs. Kantrowitz and Lin of Avco Research Laboratory appears to offer a useful means for decoy discrimination.

Their estimates of the radio-frequency and optical characteristics of the re-entry ion cloud disclose differences in such properties as trail length, trail diameter, electron density, total radiated energy, etc., and in the variation of these properties as a function of height. By exploiting these characteristics, it would probably be possible to distinguish those decoys which, until recently, were regarded as adequate to fool the system. Unfortunately, this new information also provides the challenge to design even more sophisticated decoys, and such work is currently underway in the U. S. This is, of course, the familiar measure, countermeasure, counter-countermeasure progression.

The discussions concerning decoy discrimination highlighted the urgency and importance of a well-planned program to examine Soviet nose cones during the re-entry phase. Adequate knowledge of the characteristics of Soviet nose cones and of any Soviet decoys which might be developed may be a decisive factor in our ability to confront the enemy with a potentially effective system. The Panel believes that an observation program, carefully planned to obtain as much useful data as possible, is deserving of a major effort. While conventional radar observations and infra-red photographs are useful, they are insufficient for this purpose. Special instrumentation is required to get much of the information believed to be available during re-entry, however, it appears that such instrumentation can be assembled from components which are now available.

ACTIVE DEFENSES - NIKE-ZEUS

General

The Nike-Zeus system (as are all AICBM systems) is appallingly complex in concept and in required performance criteria. No system which can approach such performance requirements has yet been demonstrated in test or practice. Nevertheless, 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. The system appears to have been well designed from a data processing point of view, and the discrimination radar has a very good range resolution capability. It appears that the presently-conceived Nike-Zeus system can be made to function satisfactorily, in a technical sense, against simple attacks involving no more than very elementary tactics of confusion by an enemy.

Nonetheless, we have a somewhat uneasy feeling that there is not enough planning for future needs in this system. The Panel feels quite strongly that the research programs should be continued and that every effort should be continued to get an experimental system into operation at the earliest possible date. This system should be sufficiently flexible to permit perfection without substantial replacement. At the same time, we urge the initiation of a parallel R&D effort to perfect measures for system hardening, a higher frequency capability for the acquisition radars and an effective capability in the presence of advanced confusion techniques.

High Altitude Effects

The problems of attenuation and refraction which may result from high altitude nuclear detonations, including those of the Nike-Zeus warhead itself, have received some study. It appears that the principal effect will be a temporary reduction in the range capability of the 500 mc acquisition radar in the direction of the detonation. The Panel believes that the problems associated with beam refraction and radar clutter, resulting from high altitude nuclear detonation, should receive further study in terms of their effect on the overall system capability.

It is apparent that the effects of very high altitude detonations (100-1000 km.) of high yield (greater than 1 megaton) nuclear devices have not received sufficient study. There is serious concern that the effects of such an explosion might persist for rather long times and could adversely affect the Zeus system performance over an extensive region of space. This problem should receive further theoretical study.

The Panel believes that present efforts to provide a higher frequency transmitter and antenna for the acquisition radar are totally inadequate. Furthermore, we feel that it is within the present state of the art to provide the components for higher frequency operation and that their development should be carried out in parallel with the present 500 mc development. This work should receive sufficient support to permit incorporation of the new, high-frequency components into the initial Zeus deployment rather than

permit the less desirable, low-frequency equipment to go into large-scale production.

Hardening

One of the publicized advantages of the Nike-Zeus AICBM system is the protection of population centers. Although this capability may be of real value in certain circumstances (discussed on page 11 of this report), the Panel feels that any protection which can be achieved in this way will remain far from adequate to influence, in any serious way, the military policy of a potential attacker. We believe that the effective contribution of Nike-Zeus is to be looked for in the problem of protection of the retaliatory force. Whatever the merit of other possible applications, the presently-conceived Nike-Zeus system is of doubtful value for the protection of hardened missile bases. This results largely from the vulnerability of major system components to the effects of near-miss nuclear detonations. It is now estimated that the present Nike-Zeus system can only withstand overpressures of the order of 2 psi. By using multiple antenna installations, this weakness can be overcome to some extent and at considerable additional expense, however this is a glaring weakness in the system. There is, at the present time, no known way to obtain a really hard antenna system, but this problem is one of sufficient importance to warrant much more attention than it is now receiving. These comments apply to all of the antennae of the Nike-Zeus and not to the lens alone.

The Panel therefore believes it highly desirable to explore all possibilities which may permit the hardening of major Nike-Zeus system components.

Developmental Production

The Panel was informed that an expenditure of approximately 150-200 million dollars will be required in fiscal 1960 to make preparation for production of certain critical items for Nike-Zeus. It is stated that this effort will contribute substantially to the experimental program. The Panel did not have an opportunity to examine the validity of this statement, nor are we in a position to evaluate a detailed justification of this expenditure. There is some reason to suspect that certain of the required production facilities could be supplied by private industry if they were so requested.

The Panel concluded that an expenditure of approximately this amount is justified if it is, in fact, required to retain the presently programmed development schedule. It should be understood, however, that this conclusion does not imply approval of all of the technical features of the presently envisioned Nike-Zeus system. We again emphasize the urgent need for additional efforts in the areas of system hardening, a high-frequency capability in the acquisition radars, and an effective capability in the presence of advanced confusion techniques.

The Panel further concluded that it will not be possible to make recommendations concerning large-scale production of the Nike-Zeus system unless, (a) the doubts regarding the performance of the low

frequency components of the system are resolved, and until (b) a policy decision defines the mission of the Nike-Zeus system (i. e., is it to be designed for the defense of hard targets or for the defense of cities ?). If defense of hard targets is the objective, then the presently-conceived system, without hardening, is of very doubtful value. If, however, the primary objective is the defense of population centers, then the function and value of Nike-Zeus in the over-all anti-ICBM effort should be evaluated in accordance with questions raised in those sections of this report concerned with "The Value of Active Defenses," and "Protection of the Retaliatory Force."

OTHER POSSIBILITIES FOR ACTIVE DEFENSE

ARPA Anti-ICBM Concepts

A member of the ARPA staff reviewed a portion of this agency's program in the AICBM field. Though their overall ballistic missile defense program does contain many good projects, we were seriously disturbed by several points brought out in this particular presentation. Subjects such as radar "deathrays," anti-gravity, anti-matter and magnetic "walls" in space were mentioned. We were also informed that contracts had been placed with several companies to prove that "something" is not feasible (and as far as we could ascertain, the "something" was to be selected arbitrarily by the company).

While these projects may have more justification than appears superficially, we were seriously disturbed by them and fear that the entire military-technical effort in ARPA can be discredited by such an approach. These subjects appear more suitable for a brief discussion involving really qualified scientific personnel than for contract investigations totalling well over a million dollars.

Infra-Red Missile Tracking Systems

The Air Force (ARDC) presented to this Panel a conceptual study of a missile intercept system employing airborne infra-red detection and tracking equipment to control either ground or air-based defensive missiles. This concept appears to lie beyond the present state of the art, however, the Air Force plans to press invention in the critical areas.

There appears to be a large amount of development work in this field being sponsored by the three services and by ARPA. It appears highly desirable to have a general assessment of this effort.

THE VALUE OF ACTIVE DEFENSES

This subject 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 over-riding 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.

PROTECTION OF THE RETALIATORY FORCE

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.

One of the measures for passively defending the retaliatory force -- hardening -- progressively decreases in effectiveness as the aiming accuracy of the attacking ICBM is improved. Therefore, in the long run, active defenses become more effective relative to hardening, although not in an absolute sense. Furthermore, an active defense system which is itself hard enough to ignore near misses could add an effective increment of defense to a concentrated target (e.g., a missile base) which is already hardened. Whatever the merit of other possible applications, the presently conceived Nike-Zeus system is of doubtful value for the protection of a

hardened target. Furthermore, the Nike-Zeus system, even in its present concept, cannot be ready in an operational deployment before 1964-65.

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 parallel R&D effort be initiated to investigate the possible means for system hardening and greatly improved anti-confusion techniques. It must be again emphasized, however, that this research and development program is not an alternative to the immediate and effective exploitation of passive tactics for defense of the retaliatory forces.

SPECIFIC RECOMMENDATIONS

As a result of our study of the current status of the U. S. anti-ICBM capability, the Panel feels obligated to set down the following General Recommendations:

1. The pursuit of an aggressive program to exploit the tactics of dispersal, hardening, concealment through mobility and quick reaction upon early warning as the basic anti-missile defense of the U. S. retaliatory force.

2. The early initiation of a well-designed program to observe Soviet re-entry bodies.

Based upon our examination of the Nike-Zeus program, we recommend the following:

1. Continuation of the present research and development program in an effort to get an experimental system into operation at the earliest possible date. (This experimental system should be sufficiently flexible to permit perfection without substantial replacement.)

2. The expenditure of a modest sum (150-200 million dollars) if this sum is, in fact, required for developmental production to retain the presently programmed development schedules.

3. The initiation of a vigorous, parallel research and development effort 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.

4. Further theoretical investigation of the effects of very high altitude detonations (100-1000 km) of high yield (greater than 1 megaton) nuclear devices on the Nike-Zeus system.

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