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May 12, 1958

MEMORANDUM FOR DR. KILLIAN

The AICBM Panel had its third meeting on May 2nd and 3rd. The Panel members attending were:

J. B. Wiesner, Chairman
W. E. Bradley
Harold Brown
W. K. H. Panofsky

In addition, the following people were invited to be present for this meeting:

R. F. Bacher - PSAC
H. A. Bethe - PSAC
E. M. Purcell - PSAC
Herbert York - PSAC
William Graham - Rand Corp.
Richard Latter - Rand Corp.
Donald Ling - Bell Tel. Lab.
Clifford Warren - Bell Tel. Lab.

The remainder of this memorandum consists of summaries of the discussions of the major topics considered during the meeting. In particular considerable attention was given to the problems associated with the NIKE ZEUS system, since this system is ~~not~~ NOW the only AICBM system being actively pursued by the DOD, the Talos AICBM system R&D program having been completely stopped within the past month.

The Panel did not spend a great deal of time examining the organizational problems discussed in its first report, however, we would like to point out that many of the problems highlighted in that report, particularly those associated with adequate experimental and test programs still are critical.

confirm S-RD
CF Luce
OCT 8 1975

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NIKE ZEUS ANTI-MISSILE MISSILE SYSTEM SCHEDULE

The Nike Zeus system has been under development for the past two years. It is presently authorized as an urgent Research and Development program with the objective of demonstrating in the second quarter of 1961 at White Sands Proving Grounds (WSPG), the capability of the system to defend against ICBM and shorter range ballistic targets.

Major development effort is being directed to the powerful acquisition and tracking radars required for ballistic targets. These radars will be installed at WSPG by late 1959 and early 1960 which is expected to permit a full year for radar tests prior to the full system demonstration. A Nike Zeus tracking radar is also planned for installation at a ballistic missile impact area by early 1960 to test experimentally its capability to track re-entry nose cones which has not yet been done in this country and to study the problem of discriminating against decoy objects.

First flights of the high performance defensive missile capable of intercepting targets up to about 150,000 feet are scheduled for July 1959 with six flights in 1959 and about 50 in 1960. First flights of the missile with a thrust vectoring nose giving intercept capability up to 500,000 feet are scheduled for 1960.

Preliminary studies are under way, within the framework of the present Nike Zeus and without interfering with the present

Nike Zeus development, to determine what can be done to provide a higher frequency acquisition radar in the event that experimental tests indicate that "blackout" or Argus Noise is a serious problem at the present acquisition frequency.

FUNDING AND DEPLOYMENT OF NIKE ZEUS

General John Daly gave the group a short resume of the current fiscal situation and a status report on the state of planning for deployment of the Zeus anti-missile defense system.

At the present time there is no firm Department of Defense program for the purchase and deployment of any operational anti-missile equipment. The original Army plan was to make the procurement and deployment decision concerning the Zeus system after the system demonstration tests sometime in mid to late 1961. This would probably permit deployment of operational units to begin with the first batallion on site during the third quarter of 1963.

As a result of the recent concern over the Russian progress in the ballistic missile field the Army revised its schedule and requested additional support for both the R&D and production programs. They proposed a new schedule which, if none of the foreseen difficulties developed, would have permitted three batallions on site by the last quarter of 1961. For such a schedule to be met required a go-ahead to the manufacturing contractor by April 1, 1958, considerably before the first system demonstration is to be carried out. The date of the first equipments for operational use would then have been the first quarter of 1962 and will now slip back until the necessary contractual arrangements are made. The Army would have needed approximately $600,000,000 additional expenditure authority in FY '58 and FY '59 to

meet the earlier date.

The Army expects to have a large sum of money ($242,710,000) in FY '59 for the R&D program including buildings and other facilities needed for the test program at White Sands and for contractor facilities needed to produce the two original equipments. Approximately $44,000,000 of the FY '59 money will be used for such facilities, primarily for facilities required to produce the large antenna systems and radars. This investment will also contribute to any follow-on production. Approximately $7,000,000 of FY '59 money will be used to begin site studies, land acquisition, etc., so that when a decision is made to implement the program these very long-lead time arrangements will be well under way.

At the present time, the Army has insufficient funds to permit an effective build-up of the current R&D effort to the level contemplated in the FY '59 budget. Since FY '59 money may not become available until August or September, the Army has requested $16,100,000 additional for immediate expenditure and believes that these funds will shortly become available. Unless this happens the R&D program will not be operating at an optimum level (they say, the Committee did not look at the fine-grain details of the program) until the FY '59 money actually becomes available.

NUCLEAR WEAPONS FOR ANTI-BALLISTIC MISSILE SYSTEM

Several methods have been suggested for destroying an enemy ballistic missile or its nuclear warhead. However, using nuclear weapons now appears to be the only feasible means. Nuclear warheads provide a variety of effects. Of these, [redacted] known to be important. [redacted] For the [redacted] weapon currently planned for the Nike Zeus missile, an enemy warhead would be destroyed at distances of the order of [redacted] However, this lethal distance depends on the detailed design of the enemy warheads--it could be larger but is unlikely to be much smaller [redacted] of the enemy warhead is provided at considerable cost in warhead weight or yield. [redacted] The [redacted] effect is produced by [redacted]

[redacted]

Of these [redacted] effects, the [redacted] reliable appears at present to be [redacted] The Nike Zeus system was designed [redacted]

[redacted]

[redacted] Theoretical calculation of these is likely to be unreliable so that experiments on these effects will undoubtedly be necessary. Such experiments cannot even be designed, however, until theoretical calculations indicate promise. Special weapon designs probably

will have to be developed to exploit these ideas. If order of magnitude increases of lethal radii can be achieved, this would profoundly affect the current concept of missile defense.

The [redacted] series contains a number of test devices which provide possible warheads in the weight range suitable for the Nike Zeus system, including [redacted] categories, with yields in the [redacted] range. Tests after [redacted] might be expected to increase whatever yields are obtained at that time [redacted] If the kill radius is considered marginal in view of the possible degradation of the expected miss distance [redacted] the higher yield of the heavier warhead may indicate its use, providing that the penalty in missile velocity and hence maneuverability does not increase the miss distance still more. If economy in reactor product is of overriding importance, [redacted] A warhead without any [redacted] could not be stockpiled without further test.

No [redacted] warheads will be available after [redacted]

[redacted] since the warheads tested in it will get about [redacted] respectively of their yields from fission. [redacted] warheads [redacted] will be tested, so one might expect that another cycle of development and testing would be sufficient for the development of a [redacted] warhead, and perhaps two cycles for [redacted] warhead, in which the fission was [redacted]

Clean warheads would reduce the world-wide fallout from the use of anti-missiles, but this would in any event be small. The anti-missile altitude and yield are such as to eliminate local fallout and rainout even if the weapons are not clean unless there are some accidental detonations at ground level. Clean warheads for this purpose would, even after their development, be [redacted] by a factor beginning at [redacted] Since the use of a clean warhead in the Nike Zeus weight and yield range appears to have little effect on the fallout problem and substantially [redacted] the system, its use would not appear to be indicated. This conclusion does not necessarily apply to possible anti-missile warheads of greater yield.

NUCLEAR TESTS AND BALLISTIC MISSILE DEFENSE

The effects of [redacted] principally because of our [redacted] about possible incoming ballistic missile warheads. Our [redacted] of the effect of a given defensive warhead on a [redacted] enemy warhead is fairly good, and subject to comparatively small [redacted] Calculations on such effects are quite [redacted] Further experiments on [redacted] Though better experiments [redacted]

Though a systems check of the Nike Zeus system including a nuclear explosion would increase confidence in its efficacy, the operation of the [redacted] is sufficiently well understood that little would be gained so far as that problem is concerned.

About [redacted] we have some theoretical knowledge, and a general idea of their effects. The phenomena involved are more complex than for [redacted] and therefore require more normalization to experiment. A small fraction of the experiments might be done in the laboratory. Because of the dependence of the effect on the character of the defensive warhead and on the behavior of the incoming nose cone (even if its characteristics are known) to a flux of energy whose characteristics are not achievable in the laboratory, nuclear tests are required for

investigation of the phenomena. Many of these tests need not be done at high altitude but can be done on or below the ground. A start on some of the problems connected with [redacted] phenomena will be made in connection with the [redacted] but this deals principally with the nature of the [redacted] and very little with the effect on possible targets. In any event, [redacted] will probably raise more questions about [redacted] than it answers.

Of the possible effects at high altitudes which might prove to produce a lethal radius greater by an order of magnitude than [redacted] still less can be said, since it is not known whether they exist. It does seem possible that trapping of the energy in a large volume may be done by suitable choice of altitude and design of the warhead, but it will even then remain to be seen whether the time of energy trapping and nature of the energy flux [redacted] are such as to do the necessary damage. Very little, if any, information on any of these points will be derived from the [redacted] shot, because it seems clear from calculations done up to now that such phenomena, if possible at all, will not occur at an altitude as low as [redacted] feet. Nevertheless, [redacted] if successfully instrumented, will greatly increase our general knowledge of [redacted] effects. The exploration of such new effects, which would have a decisive result in the AICBM problem, would depend completely on subsequent nuclear tests because of the strongdependence of the effects on defensive warhead design, choice of altitude and non-equalibrium processes. [redacted]

RADAR BLACKOUT CAUSED BY HIGH ALTITUDE NUCLEAR EXPLOSIONS

Nuclear explosions produce intense ionization of the atmosphere surrounding the burst point. This ionization extends over large distances for explosion altitudes above 10-20 miles. The free electrons produced in this process absorb energy from a radar beam and dissipate it in collisions with ions or neutral molecules. As a result, a region in the vicinity of the burst, which may be many miles in extent, becomes temporarily opaque to radar transmission. This absorption has been termed "Radar Blackout."

Another important effect of a very high altitude nuclear explosion is the production of refractive effects and strong reflection from the highest layers of the atmosphere. These effects interfere with target tracking accuracy, and in the case of strong reflection, confuse the radar by echos from the ground.

These effects would result from the explosion of defense weapons above about 100,000 feet during operation of the defense system and hence exist independently of enemy tactics. The enemy could increase the effects greatly by exploding a large fission yield weapon at the most effective altitude.

Considerable uncertainty attends calculations of the duration of serious radar absorption. Duration in excess of [redacted] would be troublesome to a missile defense target tracking radar. Calculations based upon the best available physical data predict serious blackout for longer than [redacted]

yield at 50 mile altitude.

Calculations reliably indicate that the refraction and reflection effects occur at higher altitude than the absorption effect [redacted]

The high altitude explosions of the [redacted] series planned for late summer [redacted] if the instrumentation operates as planned, will provide basic data for future accurate calculations of radar blackout.

Radar absorption is theoretically less severe and much shorter in duration at higher radar frequencies. [redacted] Severity of refraction and reflection also is much less at frequencies above [redacted]

Most proposals for defense against ballistic missiles, including Nike Zeus have been based upon long range target acquisition radars operating on frequencies [redacted] If the blackout is as serious as the recent calculations indicate, such radars will not be satisfactory and must be completely redesigned for higher frequency operation.

It is possible that, in addition to changing to [redacted] acquisition radar frequency, a change in system concept of Nike Zeus may be necessary. Such a concept might for example provide for location of the long-range radars away from regions of probable high altitude nuclear explosions.

THE ARGUS PHENOMENON (CHRISTOFILOS EFFECT)

The Argus effect is concerned with the military effect of high energy electrons trapped in the earth's magnetic field at high altitude. The sources of such electrons (in addition to natural sources) are: (a) electrons arising from the decay of neutrons emitted by nuclear weapons at altitudes sufficient to permit neutron escape [redacted] (b) electrons from the decay of fission products can escape upward from a nuclear blast (this might become possible as a result of a weapon fired at altitudes [redacted] (c) electrons from the [redacted]

At present it is certain theoretically that this trapping can occur. The trapping time depends on altitude and electron energy. The density of electrons is limited by stability problems. [redacted]

The most likely effect of the Argus phenomenon of immediate military consequence in connection with AICBM is the generation of radio noise. This noise could seriously hamper the performance of certain radars and communications. Systems operating above [redacted] are safe from neutron decay electrons while systems above [redacted] safe from fission escape electrons. In intermediate regions, the deterioration of performance depends on the noise margin of the system and the lifetime of the phenomenon.

Other effects of Argus of anti ICBM importance need much larger electron concentration and would require a large number of special weapons; it is doubtful at this time whether such amounts would be stable. Hence the noise effect is the only problem about which enough is known to make it of immediate significance.

Presently trapped electrons as observed by Explorer I and III. Results of J. A. Van Allen with a Geiger counter in Explorer I and III indicate very high electron concentration at low latitudes and at altitudes above 700 km. These are important here in several connections: (1) as experimental evidence for trapped electrons, (2) as a source of interference with conducting tests on the Argus phenomenon, (3) the question of whether the electrons seen by the Explorer possibly originate from the Russian tests is obviously of interest. The satellite results are somewhat qualitative since the instrumentation did not anticipate the high fluxes incurred. Nevertheless the character of the signals under overloaded conditions permits some quite reliable inferences to be drawn. If the counts were due to the Russian tests then these electrons would originate either from neutron decay electrons or fission escape electrons. In this case a corresponding increase in radio frequency noise level would be observed.

Preliminary analysis of noise data at Stanford Research Institute indicates that no increase in noise temperature of [redacted] in excess of [redacted] were observed at night during the period of the Russian tests.

We conclude that it is unlikely that the observed counts as seen by the Explorer are due to the Russian tests. However, considering the crudeness of the calculations and the importance of the question, these calculations should be improved and noise records, if existing, at somewhat lower frequencies should be searched. It is most likely that the electrons observed by the satellites are in the low energy (0.1 MeV) group. These would not generate noise observable through the ionosphere. This view is consistent with earlier observations by sounding rockets in the aurora.

Test plans. A test program involving a special [redacted] shot has been formulated and is being carried out under direction of ARPA. The test shot is to be fired off the Navy carrier Norden Sound using the XM-20 solid propellant re-entry test vehicle. The shot location is in the South Atlantic. Aurora measurements at the magnetic conjugate in the Azores or in Morocco are planned.

It is planned to launch two satellites specially instrumented with scintillation counters to sort out the various energy groups. This instrumentation is to be provided by Dr. J. A. Van Allen's group at Iowa State on a desperately short schedule; environmental testing and preparation of the satellites is to be handled by the Jet Propulsion Laboratory, Pasadena. The entire test operations are to be completed before September.

Considering the complicated nature of the planned operation, the chance of failure of each part of the operation, and the unprecedented

brevity of the schedule, success of this test is far from certain. Nevertheless, if any one of the satellites is launched successfully, essential basic data concerning the natural electrons can be gathered.

We believe that the test, if successful, will yield essential information; plans for further tests can be deferred until preparations for the current Argus test are established.

DISCRIMINATION OF A BALLISTIC MISSILE WARHEAD FROM DECOYS

It appears to be feasible to equip a ballistic missile with decoys which accompany the warhead during its flight through space and which may be difficult to distinguish from the warhead by radar or by any observation system yet devised. Such decoys are technically much less difficult to design than other parts of the long-range missile itself.

Theoretical and laboratory experimental studies of the subject have been made, however, it is not yet known whether decoy discrimination will ever be confidently achieved with any means yet proposed.

Decoy discrimination at present appears more likely to be possible within the atmosphere during re-entry than during the space portion of the flight. Unfortunately, atmospheric discrimination cannot be used until the last minute or so of flight, requiring interception at relatively low altitudes (40,000 to 120,000 feet in most cases).

Lack of flight experimental data handicaps decoy discrimination progress. A down-range testing program wherein missile and decoy re-entry could be observed at an earlier date than presently programmed with adequate instrumentation is very much needed.

Since much information on decoy discrimination is theoretical, there is some possibility that actual experiments may show that the problem has been exaggerated or that some unsuspected phenomena, favorable to discrimination, may exist.

Discrimination based on the mass of oncoming objects would be sound, since the delivery of heavy objects seriously penalizes the offense. The policy would be to intercept any object having a mass great enough to contain an important weapon.

Most studies of decoy discrimination at the present time are aimed, probably mistakenly, at less fundamental attributes of the objects such as radar scintillation, ballistic drag coefficient, etc. A few investigators have suggested principles which might permit inference of the mass of oncoming objects, but none of these ideas has yet been tested or studied extensively.

Multiple warheads for an ICBM, separated during space flight, are probably feasible with weapon knowledge in either USSR or U.S. These are indistinguishable from heavy decoys and must be fired upon by the defense system. Mass is therefore the only reliable decoy discrimination criterion.

CONCLUSIONS

1. Primarily due to the blackout effect and also due to the Argus effect the performance of the Nike Zeus system could be severely limited. In addition, anti-decoy performance is still most doubtful. There is, therefore, at this time no assurance that deployment of a Nike Zeus system or any other known active defense system will achieve AICBM defense by the date of 1963 as originally planned.

2. Even if the Nike Zeus system were available today, radar blackout might make its performance uncertain against present missiles. Considering the improvements possible in the missile parameters we believe that anti-AICBM efforts along the lines of the present technical approach will continually lag in effectiveness. We therefore believe that at this time we cannot assume in military or political planning that this country will have an anti-ICBM defense at any time commensurate to the anticipated threat.

3. There is a possibility that shifting the frequency of the radar to higher frequency will remove some of the radar difficulties. Such a change can lead to anything from a modified to a radically redesigned system. In either case, it is certain that the lack of available and tested powertubes at higher frequencies will limit the schedule which can be attained.

4. All kill mechanisms of the enemy warhead involve the use of atomic warheads. The most likely kill effect

[redacted] this effect can be evaluated confidently without additional testing. The quantitative analysis of other kill effects such as [redacted] would require further tests. Possibilities exist that kill radii larger than those predicted [redacted] (which forms the design basis of the Nike Zeus system) exist; these have to be studied theoretically followed by experimental test if the studies indicate such promise.

5. As time progresses, we will be faced not only with the decoy problem but with the possibility that a number of small but high yield weapons may be included in a single warhead and dispersed just prior to re-entry, thus making it necessary to take action against more than one incoming object even if the decoy discrimination problem can be completely solved.

6. We believe that in view of the uncertainties discussed above, other techniques including proper use of infra-red devices, the possibility of passive electro-magnetic emission, the low-frequency reflection from ion trails and interception by a high energy electron beam, to name a few, should be investigated theoretically or experimentally, sufficiently enough to see if they might not provide the interception, detection and discrimination techniques required for a successful anti-missile system.

7. It is likely that changes to higher frequencies in this and other systems will be necessitated by the effects discussed in this paper. It is urgent that a much intensified high frequency high power tube program be started at once. The Science Advisory Committee should recommend prompt action in this area.