91-FOI-1852

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
WASHINGTON 25, D. C.

10 AUG 1963

MEMORANDUM FOR THE CHAIRMAN OF THE JOINT CHIEFS OF STAFF

I attach a copy of the document which I am sending to McGeorge Bundy in response to the President's request in NSAM 254.* Earlier drafts have been seen by the Joint Staff and some of their comments have been incorporated. I know that The White House would appreciate any additional comments or observations which the Joint Chiefs would care to make on the matter.

Harold Brown
Harold Brown

* Enclosure to JCS 1731/721

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CONTROL 26

Copy No. Original
Case No. 91-FOI-1852
T.S. No. 91-TS-179
Document No. 1

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Log No. 57546
Copy No.

10 August 1963

DRAFT REPORT ON EFFECTS OF A NUCLEAR TEST BAN WHICH ALLOWS TESTS UNDERGROUND

1. Introduction

This is a report in response to NSAM 254, which requests a Defense Department evaluation of the effects of a nuclear test ban which permits underground tests.

The effects of a complete test ban have been examined before with respect to a) what it denies the U.S. and the Soviet Union in terms of further development and corresponding military improvement, b) the possibilities for evasion and consequent unilateral gains by the Soviets, and c) the possible advantages of such a test ban in areas outside the weapons systems balance. However, the prospect of a partial ban on nuclear tests, permitting underground testing, has prompted a further analysis of the problem in this new context. Legalization of underground testing changes the situation as regards benefits to be gained by illegal tests. It therefore alters the motivations for cheating in the atmosphere, underwater and space, and allows us to examine a more restricted set of possible purposes for clandestine testing.

The following parts of this paper deal with: the purposes and advantages to be gained by the Soviets in illegal tests in the atmosphere, underwater and in space; the nature of such tests in terms of cost, time to carry them out, and extensiveness of facilities required; and the detectability of such tests by the physical means of a test detection system, or by various intelligence means.

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II. Summary

One can conclude that given an opportunity for legal underground testing, much but not all of the motivation for testing in other media is removed. A comparison of detectability of various kinds of tests, the purposes for which they might be carried out, and the problems associated with avoiding detection (directly or by intelligence means) lead to the conclusion that strong motivation has to exist before a violation might be attempted, and further, that the violator cannot be sure that his attempt will indeed go undetected. In our view, the most important military purpose for clandestine tests would be [redacted] Even unlimited further testing in the upper atmosphere for this purpose is not expected to be decisive. However, improvements in ABM systems could be made through a better understanding of the role of [redacted] This understanding will not be complete in the absence of atmospheric nuclear tests. Other factors, of greater importance in ABM improvement, are: [redacted]

There is some uncertainty about the size of yields of tests in the upper atmosphere that might escape detection by purely physical means. It does seem that tests of [redacted] though acoustically detected, may not give debris that is precisely identifiable. However, the possibility of collecting such debris, together with the likelihood of detection of associated activities by other means, makes the risk of detection very high.

Considering our estimates of the current state of nuclear and space technology, even if tests were allowed, the U.S. would not plan for at least the next several years, if ever, to conduct a program of the type of deep space tests which would be [redacted] Because of low reliability, high costs and risk of being caught in any important undertaking of this kind, it is difficult to see why the Soviet Union would be sufficiently motivated to try deep space nuclear explosions. On the other hand, with weapon developments from underground testing and with space technology gains possible in six to ten years, interest on the part of the Soviet Union may arise in violating the ban on deep space tests. The situation at that time will depend on the state of development of space technology and reliability, the motivation of the Soviet Union and on the capacity of our detection and identification techniques. The state of this latter technique will be determined, in turn, by the level of support given to the detection satellite program.

Substantial, but not overriding reasons were found for our conducting atmospheric, nuclear tests. Some reasons also exist for doing underwater tests. A substantial increase in our capability of detecting violations on the part of other countries would require the establishment of a comprehensive detection network of underwater, surface and even

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satellite detectors. Depending upon the extent of this increase a violator would have to incur very substantial expenses if he wants to have even a chance of avoiding detection; in some cases avoiding detection would be impossible irrespective of expenses; in no case would a violator be sure of success.

III. Present Comparative Status of Soviet and U.S. Capabilities

With respect to weapons development, only rather over-simplified comparisons can be made. The most commonly used standard for comparing technological capabilities is yield-to-weight ratios. This is not the only relevant criterion, but it is the one concerning which we possess the most information. By this standard, the Soviet Union appears [redacted] The Soviets are approximately equal to the U.S. in [redacted] between [redacted] the U.S. probably has an edge; and below 2 MT the U.S. appears to be clearly superior in yield-to-weight ratios. [redacted]

The attached chart shows our relative position with respect to yield-to-weight ratios.

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~~relative capability;~~ [redacted] ~~with the U.S. very probably being ahead below that yield.~~

It should be noted that all of these comparisons could be in error by substantial amounts, but that there is no reason to believe that the errors are greater in one region than another. Possible uncertainties in the Soviet capability could make their actual warheads somewhat lighter or substantially heavier than we estimate.

With respect to tactical weapons, yield-to-weight ratios are both harder to come by and a poorer measure of the relative capability. In this area the overwhelming weight of the evidence is that [redacted] This is however a very qualitative judgment and may well overestimate the knowledge that we have on which to base such a conclusion. Both the U.S. and the Soviet Union can further improve the performance of their low-yield weapons on the basis of underground testing.

With respect to weapons effects tests, [redacted] Such explosions have also taken place in the Soviet Union. Although we have only limited knowledge about the nature of their instrumentation, there appear to have been some heavily instrumented shots, though perhaps not as heavily instrumented as the most elaborate U.S. tests of this kind. In any event, we know that the U.S. has a substantial amount of information in this area, but [redacted] The Soviet Union appears to be in the same [redacted] situation. [redacted] In any case the vulnerability of hard missile sites is even more sensitive to missile accuracy than to yield, and both of these are rather uncertain with respect to the other country's threat.

The effect of the so-called electromagnetic pulse on the cable connections in a hardened missile site [redacted]

With respect to high altitude tests carried out for the purpose of determining the effects of nuclear bursts on communications blackout, radar blackout, and nuclear weapons vulnerability, Soviet and U.S. experience appears to be comparable. Each side has had about the same number of tests, over yield ranges and altitude ranges which are comparable though not identical. Enough has been learned in the U.S. to verify the existence, nature, and rough dependence of blackout characteristic on yield and altitude, although important details still have not been explored. The same is probably true in the Soviet Union. [redacted] Both sides have done several tests with very extensive instrumentation. [redacted] From these techniques the effects on a system for the types of devices and altitudes tested can be synthesized with good confidence; much better at any rate than gross information derived on one system can be transferred to another. Probably neither side understands the phenomena sufficiently well to permit theoretical extension with complete confidence to some other altitudes, yields, and types of devices [redacted]

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[redacted]

With respect to the situation on the anti-ICBM problem generally, the most important elements are design of the radar and missile systems. Neither of these depends in detail on the development of one's own nuclear warheads, although warhead performance especially with respect to radar blackout and kill mechanism do influence the optimum point of design of the AICBM system. Warhead improvements can produce an improved system, but the warhead development tests, as opposed to relevant effects tests, can be carried out almost entirely underground. In the weight range which is of interest for warheads in those advanced AICBM systems that are likely to be even marginally effective, the U.S. has a substantial lead in yield-to-weight, [redacted] Both the U.S. and the Soviets can carry out further developments of this kind. Effects tests such as related to self-kill and mutual blackout have an important but not decisive influence on system design. Failure to obtain this information will require us to overdesign to provide a margin of safety against these factors, with a resulting reduction of effectiveness.

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But before this becomes the limit, a number of other problems (discrimination, etc.) must be solved. This will be discussed in detail below (Section V-b).

We will compare here briefly the relative status of U.S. and USSR ABM capabilities. The U.S. program has consisted of [redacted] The total 1964 budget for this is approximately $450 million. There is no deployment of any system at present. The NIKE -ZEUS system is being tested in the Pacific but without exploding the nuclear warhead of the interceptor during the system's tests. (The NIKE-ZEUS warhead has, however, been tested separately.) There are substantial associated activities at White Sands and elsewhere.

The Soviet Union program consists of a large development program at Sary Shagan, [redacted] The USSR has probably tested system components, possibly all of the system, but certainly without exploding the nuclear warhead of the interceptor during the system tests.

In summary, the best present judgment is that our development efforts are comparable in magnitude and success with those of the Soviets. [redacted]

[redacted] The U.S. penetration aids now or soon going into inventory are almost certainly very effective against the Leningrad system; U.S. nuclear testing in the atmosphere would not make them more so. U.S. penetration aids now under development will be effective against much more sophisticated systems.

In other words, with or without U.S. nuclear tests, the U.S. penetration aid capability gives us confidence that our missile systems will penetrate presently designed ABM systems with a large margin of safety. Development and massive defensive deployment of a more advanced system would take a number of years which would give us enough time to develop more advanced penetration aids and deploy more missiles. Hope for a really effective AICBM depends on future developments. Nuclear effects and warheads are among these, but only two of many factors.

It is important to be clear here about how long it is likely to take to produce a change in the strategic balance by introduction of an anti-ballistic missile capability of new design. As was pointed out, the ABM problem involves capability to acquire early, to discriminate decoys from warheads, to handle large volumes of traffic, and to hit and kill the targets. Most of these problems have little or nothing to do with further nuclear testing. Conversely, the penetration aid task is to deny to the defense as many of these capabilities as possible. The development and deployment of an AICBM system takes eight years from start of design to IOC, if the design is radically new, and about 6 years if the design is based on ample experience. For example, NIKE-X design began in 1961-2 and could be deployed beginning in 1969; NIKE-ZEUS design began in 1954-5 and could have been deployed beginning in 1962. [redacted] It takes 2 to 3 years from IOC to full deployment, and this deployment would almost certainly be detected in its early stages.

The development and deployment of penetration aids takes 3 to 5 years from start of design to IOC if the design is completely new, and 2 to 3 years if the design is based on related experience. In addition, it is relatively easy on principle, to stock in quantity a wide variety of tested penetration aids, and select and deploy the "best mix" on very short notice. (This last step need not take more than a few months.) Major changes in deployed ABM systems will generally take more time than major changes in penetration aid systems, although incremental but important changes in ABM systems could be made over a short period and might not become apparent to intelligence until deployed. This gives the clever and determined attacker an advantage in keeping his penetration aid deployment ahead of the ABM defense. Remembering that wide deployment of an ABM system will take several years, that our intelligence should give us information of its development well before then, that we can carry out very extensive development and deployment of still more advanced penetration aids in only [redacted] and that a substantial increase in the members of our offensive forces can also be made quickly, it appears that our retaliatory capability can be preserved with a margin of safety even if the Soviets do some cheating and then break the treaty, since we could resume atmospheric testing in a time short compared to those mentioned.

IV. Effect on Relative Progress in Weapon Development if Treaty is not Violated.

If the provisions of the treaty are strictly adhered to, the present differences as pointed out above, and any others that may exist, will tend to shrink more slowly than if unlimited testing were permitted by both sides. In the development of [redacted] (where we seem to be well ahead) the Soviets can indeed make gains through underground testing, but they are much less advanced in the techniques of conducting underground tests than we, and even our progress would be more rapid and less costly if above ground. Without a test ban, as in the past, we would still be more restricted than the Soviets in the use of above-ground tests because of our lack of isolated test areas and our greater regard for the consequences of radioactive fallout.

In some of the more important areas of weapons development, such as [redacted] we can progress almost as fast as with no treaty because most of that work would have been done underground by the U.S. anyway. If the Soviets want to pursue such developments, they will be more restricted by the treaty than without it.

In [redacted] little further progress could be made by either country under the treaty. The U.S., however, could build bombs, suitable for B-52 delivery, with yields of [redacted] without further atmospheric tests. We have not developed such a weapon because we have felt it was not necessary. Efficient weapons of intermediate, but sufficient yield, in large numbers, and with several dependable and survivable delivery systems, have given us a greater measure of security than a comparable investment in very large weapons with their necessary delivery systems.

The actual military worth of [redacted] is not precisely known and could not have been fully explored by the Soviets in their development tests. It will remain unknown under the treaty. We believe that [redacted] are equally or more effective against military targets than one of the large Soviet bombs.

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V. Purposes of Possible Soviet Cheating Under a Test Ban Where Underground Tests are Allowed

With underground tests allowed, then illegal clandestine tests would be detrimental to the U.S. position only if information is obtained which the country could not have obtained by underground tests. It is expected that underground tests can be carried out up to [redacted] Thus there will be no particular motive for doing nuclear weapons development tests in other media except at yields well above that value. Since it is not expected that clandestine tests for weapon development can be carried out more cheaply than legal underground tests, the purpose of tests in other media would be to develop nuclear weapons with tests of yield higher than [redacted] or to determine the effects of tests which cannot be carried out nearly as well underground.

a) Deep Space. Yields in [redacted] could be of interest to a possible violator in connection with nuclear weapons developments. Alternatively, deep space could be used for such effects tests as might be done there but not underground. It should be noted that [redacted] cannot be carried out in deep space, even in principle. Tests which are aimed at exploring mid-course intercept (which would take place in vacuum in any event) or to measure those aspects of vulnerability not connected with blast (which requires an atmosphere) cannot be carried out in space. For instance, X-ray and neutron vulnerability could be

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measured in deep space; however, they can also be and have been measured
underground, although to test the large target sizes needed for structural
response would require large and expensive tunnels.

It should be noted, moreover, that to make measurements of [redacted] is an extremely
difficult experiment to do even near the earth, and to do it millions of
miles from the earth (which will be shown later to be if anything [redacted] becomes a monumental undertaking.
Direct radar information cannot be obtained so far from the earth, be-
cause the targets will be too far away by a factor of 1,000 to 100,000.
At best one might hope to conduct, five or more years from now, deep
space tests with limited objectives, which might answer some questions
about presently unformulated schemes for mid-course intercept. Effects
tests of this type are extremely expensive and only justifiable if po-
tential savings run into hundreds of millions of dollars. Such tests
appear not to be worth the effort involved in the near future and may
never become attractive.

In the same way, effects of [redacted] cannot be measured in space. Deep space
clandestine testing, therefore, would be most useful in carrying out [redacted] which
might be difficult or expensive to do underground. They would also

obviously be very difficult and very expensive to do in space, since they would involve heavy payloads carried to escape velocities, and separate instrumentation pods to measure [redacted] Nevertheless this could clearly be done. [redacted] the Soviets probably have under development or could in any event develop within a few years a payload of [redacted] to escape and could be able to do such tests in perhaps [redacted] It would probably cost 50 to 100 million dollars per attempted launch and would take several months to reach the location selected for the test; the complexity of such a payload would cause very serious reliability problems. In view of reliability considerations, a successful nuclear test of this kind might cost hundreds of millions of dollars and take up to a year to execute, following years of preparation. A program of a number of such tests would not be impossibly expensive for the Soviets, but could only be justified on the basis of benefits which we do not foresee, and would be very unlikely to go undetected by existing intelligence.

b) <u>Upper Atmosphere</u>. The principal purpose of clandestine tests in the atmosphere from ten to thirty kilometers, [redacted] These would include: [redacted] Such factors [redacted] could as [redacted] be explored by such tests. [redacted] The weapons can be designed and tested underground; their ionization effects can be fully determined only by atmospheric tests. Such measurements might lead to a better understanding of [redacted] This type of blackout is a problem in any ABM system that is designed to be reasonably effective against ICBM systems with penetration aids.

Effects tests of this type have been performed in the past with [redacted] a very large amount of elaborate equipment, and telemetry of the results. Such an operation is quite vulnerable to detection by intelligence means and could probably not be chanced under a test ban. [redacted] A few low yield tests of this type might be sufficient to [redacted]

Another factor of importance in determining the effectiveness of an AICBM is the self-kill problem, since in defending against an incoming missile payload it may be necessary to shoot at many objects with more than one interceptor missile each. Here an important factor is the ratio of vulnerability distance of the enemy re-entry vehicle (or warhead) to that of one's own interceptor. In general [redacted]

[redacted] The ratio of the ranges of vulnerability is an important design parameter, and for this purpose the nuclear effects of one's own interceptors will have to be calculated, or preferably measured. Enough data on [redacted] can probably be measured underground to obtain a ratio sufficiently accurate for design purposes. However, to the extent that the ratio of vulnerability ranges is related to blast, underground tests will be of very limited utility in reducing the ratio and its uncertainty. Since [redacted] a very extensive (and therefore subject to intelligence detection) program would be needed to provide answers. Even so, a substantial margin of safety in the vulnerability ratio used in system planning would be required, particularly when one remembers that detailed knowledge of the vulnerability of the variety of incoming warheads will not exist, probably even for Soviet planners. This margin of safety could only be reduced by a very limited amount through a few clandestine atmospheric tests.

c) Surface Bursts. These might be attempted in order to obtain information on [redacted] A good deal of this information can be obtained from underground tests; however, [redacted] require bursts at or above the surface. To gain this data very elaborate equipment and construction would be necessary. As an example, U.S. experiments of this kind have taken up to six months or a year to prepare, and the same thing seems to be true for Soviet tests. [redacted] Tests of [redacted] have always been considered an appropriate next step in this connection, and preliminary U.S. planning has gone forward for [redacted]

d) Underwater. Measurements of effects with underwater nuclear explosions have not been as important as measurements of the atmospheric effects because many of these measurements can be performed with high explosive charges. In general, the U.S. would like to perform a [redacted] nuclear test on submarine and surface vessels, with their associated electronic gear to determine over-all vulnerability. Such a test would almost certainly be detected. The principal problems in ASW have to do with detection, location and identification of the underwater target. Kill is certain enough, given these factors, with existing nuclear warheads.

VI. Detectability and Identification

Detection and identification must be defined at the onset. "Detection" means that an event is detected but cannot be positively identified as a nuclear explosion. (Complementary information, scientific or other intelligence, may, however, serve to identify a detected event.) "Identification" means that an event is detected, and identified as a nuclear explosion. Clearly, identification requires more detailed knowledge or better observations than detection. [redacted]

Detection and identification are also to some extent matters of probability. A "good chance of detection" could be taken roughly at [redacted] of certainty, and this is often what is meant by "threshold of detection". This means a [redacted] It is very important to consider separately how the problem looks to each side. One country might make the judgment that it would consider a detection and identification system to be good if it could identify events with roughly 2/3 probability. This would give a potential violator a 1/3 chance of getting by with a violation and a 2/3 chance of getting caught. Whether a potential violator would be deterred by a 2/3 chance of getting caught would require a separate judgment, which would depend on many factors, political, military, etc., and would involve an assessment of the incentives he has to cheat, as well as the risks attendant to discovery of the violation. On the other hand, if for a given set of conditions, a 10 kt shot can be

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identified as such with high probability (say 2/3) then [redacted] One could call this the "threshold of evasion", and it is clearly substantially lower than the "threshold of detection and identification". For example, it is very likely that [redacted] -- the "threshold of evasion" --; it would be detected but not positively identified if the yield were around [redacted] the "threshold of detection" --; and would be identified with high probability if the yield were [redacted] the "threshold of detection and identification".

a) In Space. At present we have little capability for detecting tests in space. However, an effective ground-based detection system could be installed rapidly because the basic instrument development work has been largely done. With the cooperation of the Western and neutral nations, a world-wide ground-based system could be installed with the capability of detecting [redacted] test at one million kilometers, and an [redacted] test could be detected at 30 million kilometers. It is further anticipated that the deep space capability of the ground-based system can be improved even further.

An earth satellite system for detection of deep space nuclear explosions is presently under development (first launch scheduled for September or October, this year) and could be made fully operational within

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three years. With this system, the X-rays from an unshielded test of as little as [redacted] could be detected out to [redacted] It is true that [redacted] if conducted at [redacted] have a good chance of escaping detection by an earth-satellite system. However, it should be remembered that the conduct of such a test is indeed a formidable undertaking, with the always present risk of detection if something goes wrong. If necessary, such tests could be detected with [redacted]

Whether a [redacted] can be designed is an open question. In any case it would take a [redacted] in addition to underground tests before a violator could have any real confidence in [redacted] To carry out a full-scale test with such an elaborate shield would require an increase in the payload by at least a factor of two or three; thus something like [redacted] may be needed.

[redacted]

In the presence of subterfuge, [redacted]

b) In the Upper Atmosphere. From altitudes of [redacted] an acoustic signal will probably be detectable for any test over the USSR of more than [redacted] which would be required to do significant effects testing. Signals of other verification methods (e.g. pulse, high-frequency forward scatter) may be lacking, and there are natural events which give the same kind of acoustic signal. Therefore, other confirmation is needed, which might be provided with [redacted] By use of sounding rockets and high performance, high altitude aircraft, identification should often be possible for yields of [redacted] at these altitudes. It should also be noted that light will be visible directly from such tests at a very long distance, even omitting reflections from cloud layers which can carry light still farther. For example, a test at 30 kilometers altitude is within line-of-sight of an observer within a distance of 450 miles. A satellite surveillance system looking down at the earth may be able to detect such explosions optically at even lower yields, but would be expensive to install.

In the parts of the world remote from the USSR or China, such as the South Pacific, the evasion threshold could be about [redacted] and the chance of recovering a debris sample might be rather small. However, it is most unlikely that the Soviets will try to take advantage of this situation, since they would lose one of their greatest assets, secrecy. We could almost certainly follow their shipping; in addition, an upper atmosphere test would be difficult to perform from shipboard and might require several vessels properly deployed around the test point.

c) <u>In the Atmosphere</u>. <u>Small</u> tests on or above the surface in the Soviet Union are likely to be detected even if their yields are [redacted] could provide important information on the effects of surface bursts on hardened missile sites.

Even if they are designed to produce little radioactivity, however, they are sure to be detected by a number of other means. It should be noted in this connection that the recent Soviet tests [redacted] though carried out partially buried, were detected by the U.S. detection network. [redacted]

d) <u>Underwater</u>. Underwater explosions of [redacted] listening posts [redacted] could control most of the ocean areas; [redacted] installations are needed if all deep ocean waters are to be covered. Detections of tests in shallow coastal waters and inland lakes could be done by seismic means, but [redacted] Identification of the event as nuclear requires [redacted]

e) <u>Control System Costs</u>. Depending on the range of coverage desired, the expanded detection systems discussed could cost from $50 to a few hundred million per year for the next five to ten years. No especially large budget requirements are anticipated for the first few years because of gradually phasing in the different systems and the continuous upgrading which will be required to keep up with the steadily increasing capability of the potential violator. The lower numbers would permit [redacted] on the other hand, the larger amounts should be sufficient for complete coverage of the three media; space, the atmosphere, and underwater.

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[redacted]

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