OFFICE OF THE ASSISTANT TO THE SECRETARY OF DEFENSE
1400 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-1400

PUBLIC AFFAIRS

17 JAN 1995

Ref: 90-F-1989

Mr. Steven Aftergood
Federation of American Scientists
307 Massachusetts Avenue, N.E.
Washington, DC 20002

Dear Mr. Aftergood:

This letter and documents respond to your November 1, 1990, Freedom of Information Act (FOIA) request.

Your request was processed by the Office of the Under Secretary of Defense for Acquisition and Technology (A&T). COL Everett G. Hawthorne, Special Assistant for Management Policy and Programs, an Initial Denial Authority, has determined that the release of portions of the documents you requested must be denied pursuant to 5 USC 552(b)(1). These portions of the documents are currently and properly classified pursuant to Executive Order 12365, Sec 1.3(a)(2).,which pertains to vulnerabilities or capabilities of systems, installations, projects or plans related to the national security.

You have the right to appeal COL Hawthorne's decision to deny this information. Any such appeal should offer justification to support reversal of the initial denial and should be forwarded within 60 calendar days of the date of this letter, to:

OATSD(PA)
DFOISR
Room 2C757
1400 Defense Pentagon
Washington, DC 20301-1400

The total cost associated with processing your request is $52.70, of which there are no assessable fees in this instance.

Sincerely,

A. H. Passarella
Director
Freedom of Information
and Security Review

#72

Enclosure:
As stated

SUMMARY OF REPORT TO CONGRESS
ON
SHORT-TIME-OF-FLIGHT BALLISTIC MISSILES
AND
DEPRESSED TRAJECTORIES

(U) (S) Section 219 of the 1989 Defense Authorization Act requests that Defense, in coordination with Central Intelligence, provide a definition of depressed trajectories which, if used as the basis for an arms control agreement, would reduce the potential for short-time-of-flight (STOF) attacks. The Act also specifies a report detailing the problems of monitoring an arms control agreement using this definition. Our report concludes that the issue is not depressed trajectories per se, but STOF trajectories. Further, an end-to-end test of a missile system is not needed to develop a STOF capability, although confidence can be reduced if system tests which demonstrate that capability are eschewed. However, no definition which limits only system testing can prevent acquisition of a STOF capability. This is so because short-time-of-flight (STOF) trajectories must be short range, and depressing the trajectory only enhances the effect. Further, except for reentry, there are no significant uncertainties connected with STOF trajectories which must be tested in an exact simulation of the mission profile. The reentry vehicle may need to be tested in the actual reentry trajectory, but system testing involving the whole missile is not required.

(U) (S) Clearly, any rule which reliably prevents development of a STOF capability must constrain developmental and system testing, and must constrain developments not exclusive to STOF. Such constraints would interfere with non-STOF developments, would be difficult to monitor, and would likely lead to disputes caused by technical, albeit unintended, violations.

(U) (S) The Administration, sharing the Congressional concern, has tabled an initiative at Geneva which declares the U.S. intention not to conduct any flight test lasting less than 15 minutes, whether from land or sea, of a submarine launched ballistic missile having a demonstrated range exceeding 500 kM. This initiative seeks to reduce Soviet confidence in any STOF system they may have. It strikes the best balance between reducing Soviet confidence in a future STOF system and not interfering with non-STOF testing. This rule should reduce confidence in a STOF capability while allowing legitimate system developments.

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REPORT TO CONGRESS ON SHORT-TIME-OF-FLIGHT BALLISTIC MISSILES AND DEPRESSED TRAJECTORIES (U)

I. (U) INTRODUCTION

A. (U) ~~(C)~~ SUMMARY. Section 219 of the Fiscal Year 1989 National Defense Authorization Act requires the Department of Defense, in coordination with the Director of Central Intelligence, to submit to the Congress a report on depressed trajectory, strategic ballistic missiles. Specifically, the Congress required a definition of what constitutes a depressed trajectory for a strategic ballistic missile, an evaluation of U.S. monitoring capabilities for such test flights, a description of all past U.S. and Soviet missile flight tests qualifying as a test of a depressed trajectory under the definition and, finally, a judgment as to whether the Soviets could confidently deploy such capabilities without further testing. The underlying concern of the Congress as indicated in the legislation is reducing "the potential for short-time-of-flight attack on strategic aircraft or other strategic assets" whose survivability depends upon timely warning of attack.

(U) ~~(S)~~ The Administration shares the Congress's concern about the adverse impact that potential Soviet short-time-of-flight (STOF) capabilities could have on the effectiveness of future U.S. strategic forces. In addition, overall strategic stability could be enhanced by reducing the potential for STOF attacks on U.S. and Soviet strategic assets. A STOF initiative has been included as part of the U.S. initiative on Verification and Stability Measures proposed to the Soviets in June 1989. Although the threat from STOF missiles is frequently equated with the technology of depressed trajectories, the terms are not synonymous: threatening times of flight can only be achieved with short-range trajectories; depressed trajectories need not have short flight times. For this reason, the Administration is taking a broad approach which focuses on restricting the development of STOF capabilities generally, irrespective of the technical method employed.

(U) Notwithstanding the remarks above, the language of the statute requires that the Administration provide a definition of depressed trajectories. Therefore, in replying to Congress, we deal first with the subject of depressed trajectories and then consider the broader approach of the administration.

B. (U) OUTLINE. The outline of this paper is as follows: Section II provides a definition of depressed trajectories and provides answers to the points raised in paragraphs (a) and (b) of Section 219. Section III reviews the means by which one may achieve a short-time-of-flight trajectory. Section IV discusses testing requirements for STOF trajectories and the requirement for an end-to-end system demonstration. Then paragraph (a) of the Congressional tasking is addressed again in Section V in the context of the U.S. initiative to limit STOF development. Paragraph (b) of the tasking is readdressed as follows: Section VI discusses U.S. capability to monitor Soviet missile testing to detect development and testing of STOF trajectories. Section VII reviews U.S. and Soviet testing in the context of the initiative. Section VIII discusses the possibilities of the Soviets developing a threatening system while appearing to adhere to the initiative. Finally, Section IX summarizes the conclusions.

II. (U) RESPONSE TO SECTION 219

A. (U) Response to paragraph (a), Request for Definition of Depressed Trajectory.

1. (U) A depressed trajectory may be one for which the initial flight direction for the ballistic portion of flight is less than (below) that which would be associated with a minimum energy trajectory for the same range from insertion to reentry. With this definition, a depressed trajectory will invariably reduce overall flight time but is neither a necessary or sufficient condition for reducing the potential for a short-time-of-flight attack on strategic aircraft or other strategic assets.

2. (U) ~~(S/NF/WNINTEL)~~ Depressed trajectories, as defined above, are a regular aspect of testing for both the U.S. and Soviet strategic ballistic missile forces. Banning the testing of depressed trajectories would have a profound effect on current U.S. and Soviet testing practices.

B. (U) Response to paragraph (b), Report on Depressed Trajectory.

1. (U) ~~(S/NF/WNINTEL)~~ Ability to Monitor Flight Tests. The Intelligence community has high confidence that it can detect testing of trajectories which differ in any significant way from minimum energy trajectories.

2. ~~(S/NF/WNINTEL)~~ [ ]

(S) The U.S. tests its reentry systems on depressed trajectories partly as a means of simulating conditions on one trajectory which they would expect to encounter on another. [ ]

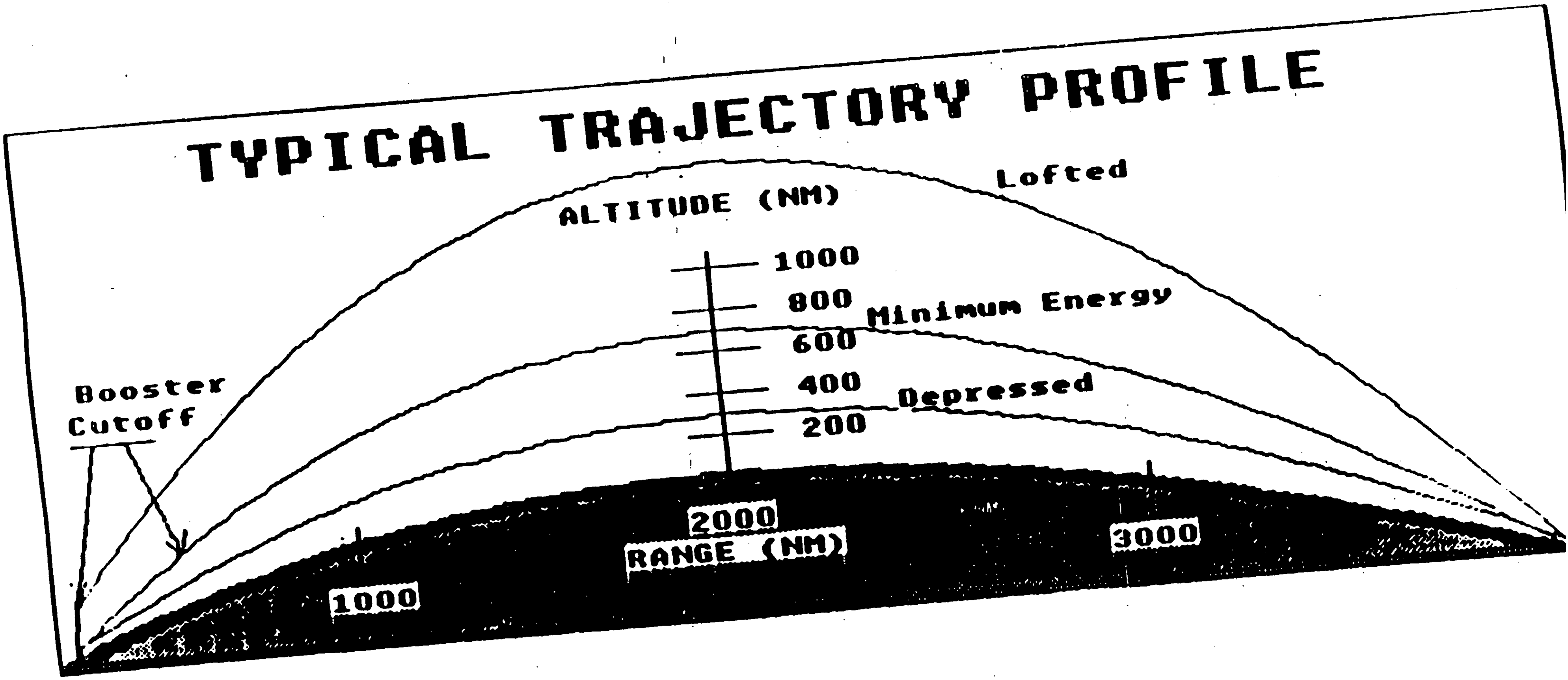
3. (U) Confidence in Reliability. Confidence will always be highest when a missile is tested in the conditions that it will be used. However, high confidence could be achieved on an untested trajectory if the missile system is flexible enough to simulate critical functions on trajectories which do not meet the definition of depressed trajectory. Present Soviet systems would probably need to be tested in the actual trajectory in order to obtain adequate confidence. Modified systems or future systems may not need such testing.

III. (U) METHODS FOR REDUCING FLIGHT TIME. A ballistic missile in the silo or launch tube possesses a given amount of energy. Usually, this energy is in excess of what is required to deliver a given payload to a given target. The excess energy is then available to achieve either a longer time-of-flight, or a shorter time-of-flight for a given payload, or it must be wasted. (Either or both of the time-of-flight options may be required to carry out structured attacks on certain kinds of missile defenses.) Alternatively, the energy may be simply wasted by flying a so-called energy management maneuver, or by terminating thrust early. Seen from the point of view of this report, the first thing that must be done to achieve a short-time-of-flight capability is to gain energy in excess of that needed to fly the range to the target. This is accomplished in an existing system either by reducing the payload (ICBMs and SLBMs) or by moving closer to the target (SLBMs). When the energy is available, then STOF is gained in a number of ways to be discussed below.

A. (U) FIRING LONG-RANGE MISSILES FROM SHORT RANGES. Reducing range to target is the most important single factor in reducing flight time. The following example will illustrate the relationship between range and time. A missile traveling 5000 miles along the minimum-energy trajectory will reach its target in about 33 minutes. Reducing the range by half to 2500 miles but still flying a minimum-energy trajectory reduces the flight time from 33 to 17 minutes. In fact, range and time are roughly proportional for all ballistic trajectories.

B. (U) DEPRESSED TRAJECTORIES. As noted in Section II, a depressed trajectory is defined relative to the so-called minimum energy trajectory, viz., the trajectory requiring the least energy to reach a given range. Any trajectory for that missile which falls under the minimum-energy trajectory is referred to as depressed and any trajectory which flies above it is called lofted (Figure 1). The minimum-energy trajectory does not result in the minimum flight time. Depressed trajectories will produce the lowest flight times, followed by the minimum-energy trajectory, with lofted trajectories achieving the longest flight times for a given range.

(U) If we consider the example above, but keep the range at 5000 miles while reducing the trajectory angle by half, the flight time drops from 33 minutes to 25 minutes, a savings of



TYPICAL TRAJECTORY PROFILE
Lofted
ALTITUDE (NM)
1000
800
600
400
200
Minimum Energy
Depressed
Booster
Cutoff
1000
2000
RANGE (NM)
3000

FIGURE 1

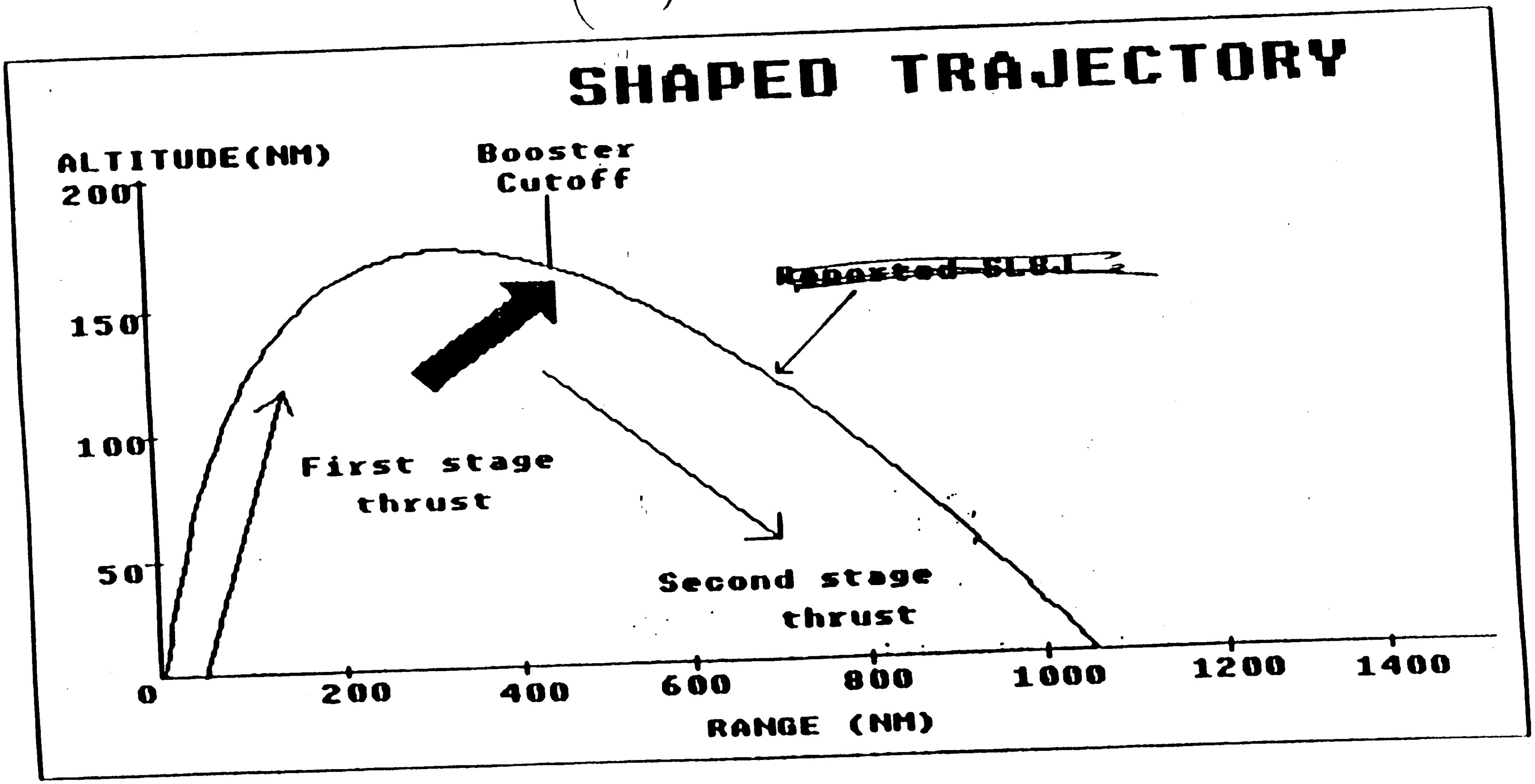
about 25%. However, halving the trajectory angle again would not reduce the flight time by the same percentage because the effect saturates as the trajectory approaches the minimum path between the two points.

(U) The discussion above illustrates the fact that threatening STOF trajectories must take place at short ranges. This leads directly to the conclusion that in order to achieve STOF trajectories, the Soviets in wartime must move SSBNs into areas directly off the U.S. coast, thereby increasing the threat to their survival.

C. (U) SHAPED TRAJECTORIES. Trajectory shaping constitutes another technique for reducing the flight time of a ballistic missile. There is no one trajectory form which qualifies as a shaped trajectory. Rather, the excess energy of the booster can be used to accelerate the reentry vehicle (RV) along its path and/or change the direction of the trajectory. Accelerating the RV along the path has the effect of increasing the range. Deflecting the RV down prevents the RV from overflying. A common trajectory used in RV flight testing involves pitching the missile sharply over after apogee and then thrusting down toward the target (Figure 2).

(U) Some degree of trajectory shaping is inevitable on a short-range flight because the time needed for the boost, guidance, and RV deployment sequences becomes a significant fraction of the total time of flight. In this case, some burning on the downward leg is almost inescapable. Like depressed trajectories, shaped trajectories can further enhance STOF capability but very low flight times can only be achieved from relatively short ranges. For that matter, a depressed trajectory could be considered a special case of a shaped trajectory in which the shaping occurs early in the flight.

(U)



SHAPED TRAJECTORY
ALTITUDE(NM)
200
150
100
50
0
Booster
Cutoff
First stage
thrust
Second stage
thrust
200
400
600
800
1000
1200
1400
RANGE (NM)

FIGURE 2

V. (U) THE U.S. SHORT-TIME-OF-FLIGHT INITIATIVE.

(S) U Notwithstanding the conclusions described above, the administration determined that the need to constrain the development of STOF trajectories was sufficiently important that some initiative was required. However, restrictive or complex rules which might proscribe certain maneuvers are either ineffective or unacceptably intrusive. Furthermore, because monitoring compliance with such rules depends on the ability to measure fine details of the trajectory, such rules could lead to endless disputes about the occurrence of technical, albeit possibly innocent, violations. Finally, a rule which permits testing at times almost as short as the time-of-flight which makes our systems vulnerable, in effect advertises that vulnerability. For these reasons, we believe that any proscription should be so broad as to eliminate any system test which remotely resembles a STOF trajectory and does so with the simplest possible requirements on monitoring.

(S) U As part of the U.S. initiative on Verification and Stability, the Administration has proposed mutual restraint on testing STOF capability. The U.S. STOF proposal would have both sides forego SLBM test firings of less than 15 minutes (launch to impact of the first reentry vehicle). The proposal focuses solely on SLBMs because only those missiles have the capability to be launched at relatively short ranges from their targets. Additionally, this measure applies to testing of STOF SLBMs on land or sea. Missiles having maximum range less than 500 km are specifically excluded.

(S) U Although both the United States and the Soviet Union have tested trajectories under 15 minutes, this proposal would prevent further testing and thus impede the testing of sea and land capabilities in the future. This proposal will not adversely affect current U.S. strategic plans or programs. While U.S. SLBMs have occasionally been tested at less than 15 minutes flight time, such testing is not essential and could be foregone.

VI. (S/~~NF/WNINTEL~~)

VII. (S/FN/WNINTEL) U.S. AND SOVIET FLIGHT TEST EXPERIENCE.

U (S/NF/WNINTEL) Both the U.S. and Soviet SLBM flight test programs have had tests in the region proscribed by the U.S. STOF initiative. It is of interest to note that both have on occasion also tested in the region proscribed by the more detailed and restrictive formula set out in the Nagle-Dornan amendment to the vetoed version of the 1989 Defense Authorization Bill. This formula sought to ban any trajectory satisfying:

$$300 \text{ nm} < R < 500 \text{ nm, and } T < 4 \text{ min;}$$

or

$$500 \text{ nm} < R < 1500 \text{ nm, and } T < 12 \text{ min;} \qquad (1)$$

or

$$1500 \text{ nm} < R, \text{ and } T < .015(.323R + 316);$$

Where

R = range,
T = time of flight.

(S/NF/WNINTEL) [

]

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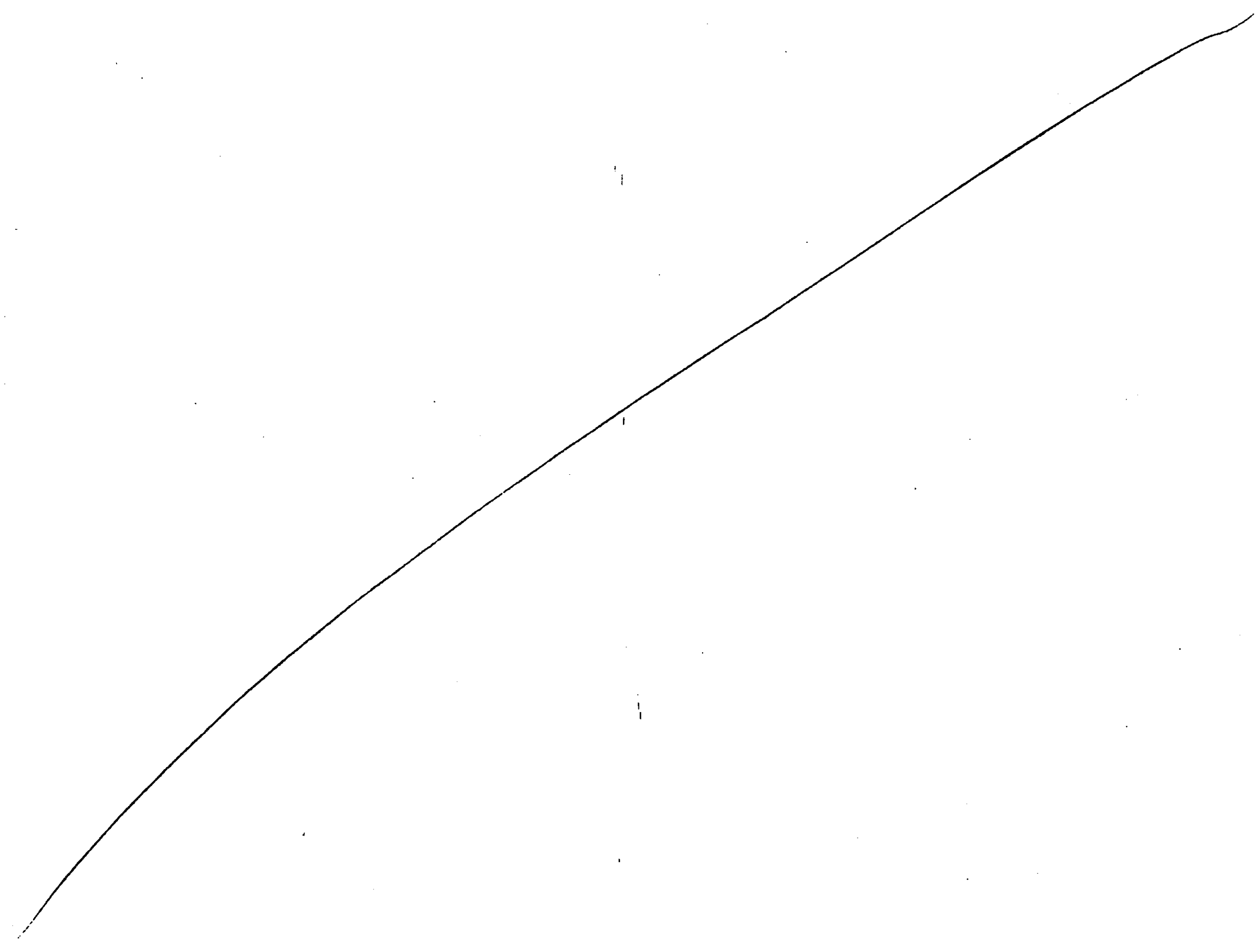

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FIGURE 3

U

(~~S~~) Figure 4 sketches in U.S. SLBM flight testing history. Test cases which most closely approach the congressional definition are indicated by numbered arrows. In general, modern RVs have been tested above the congressional line but some A-1, -2, -3, and C-3 missile tests lie below it. A test of a U.S. ICBM on a depressed trajectory took place in the 1960s and is indicated as the LARV. The reentry angle was 5 degrees, the range was 4000 miles, the flight duration was 21 minutes, and the test point fell below the Nagle-Dornan line.

(U) The U.S. has used rocket systems similar to the SL-8J in the past and has plans to do so again in the near future. The Athena booster was used at the White Sands Missile Range in the late 1960s for RV and penaid developmental testing, and was flown from Wake Island to Kwajalein Atoll in the early 1970s to gather data for ABM systems design. The Athena booster was also flown from Wallops Island, Virginia, by the Defense Nuclear Agency to test nose tips for weather erosion. The SDIO plans to use surplus Polaris parts to launch test vehicles from Hawaii to Kwajalein this year. A point representing the Athena tests is shown on Figure 4.

(U)
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U.S. FLEET BALLISTIC MISSILE
TOTAL TIME OF FLIGHT VS RANGE

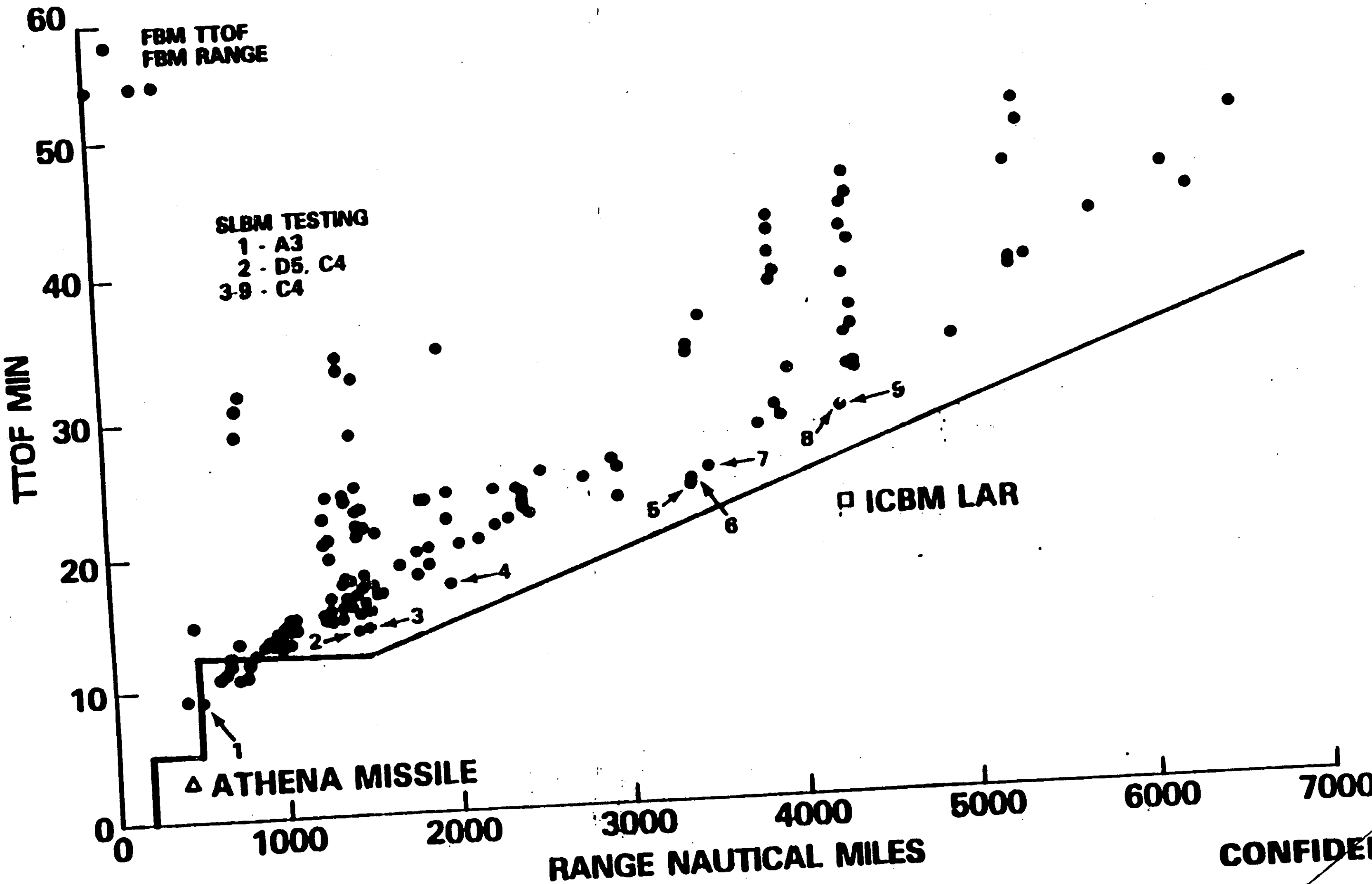

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FIGURE 4

VIII. (U) POTENTIAL FOR ACHIEVING STOF CAPABILITY

U (S) The U.S. proposal described in Section IV would inhibit the acquisition of STOF capabilities by restricting the principle means for STOF technology development, viz., system flight testing on a STOF trajectory. Although it would reduce confidence in STOF capability, eliminating flight tests lasting less than 15 minutes would not guarantee that a deployed missile does not have a reliable STOF capability. Some short-time-of-flight capability may still be achievable without full-scale testing under 15 minutes. For example, partial flight testing of shaped or depressed trajectories in conjunction with computer simulation could permit the development of a future STOF-capable ballistic missile without requiring a full-scale system test from an SSBN. It is unlikely, however, that the same high level of confidence associated with a full-scale test could be achieved through partial testing and/or computer simulation. It is less certain that the degradation in confidence would be sufficient to deter relying upon STOF systems in an attack.

U (S) Even without special trajectories, long-range Soviet SLBMs fired to short-ranges could achieve low flight times while flying minimum-energy trajectories which need not be pre-tested. A 15-minute STOF restriction cannot prevent the Soviets from taking advantage of this by deploying their SSBNs in wartime close to the U.S. coast. In terms of arms control, only coastal SSBN exclusion zones can address this threat. The U.S. has traditionally opposed such exclusion zones because they are very difficult to verify in peacetime, apt to be violated in wartime, and would significantly interfere with standard U.S. naval operations. In wartime, the coastal Soviet STOF threat could best be dealt with by attempting to sink all Soviet submarines in this area during the conventional phase of hostilities.

U (S) Finally, we note the possibility that a STOF test could be masked as a test failure given the possible similarity in time-of-flight and trajectory between a prohibited STOF test and an in-flight missile failure. This is a significant monitoring problem which was first recognized during the SALT II discussions on STOF and has not yet been satisfactorily resolved. To illustrate the problem, there were [ ] Soviet SLBM failures [ ] which would have violated the

STOF proposal tabled by the U.S. during SALT II[1]. The underlying concern is that contrived or intentional failures could be used to duplicate necessary test conditions and thus aid in the development of prohibited STOF capabilities.

(U) Finally, it should be noted that banning all future SLBM flight tests of less than 15 minutes would not erase Soviet confidence in missile capabilities they have already certified within the proscribed area.

[1] "Each party undertakes not to flight-test modern SLBMs in depressed trajectories. The term depressed trajectories refers to the trajectory of any reentry vehicle of a modern SLBM for which the apogee either is less than 275 Km or is less than the sum of 146.7 Km and the product of 0.0987 and the range in kilometers of that reentry vehicle for that flight test"

IX. (U) CONCLUSION

(S) The U.S. initiative regarding short-time-of-flight testing by eliminating all SLBM tests under 15 minutes would increase uncertainty in any future effort to develop a STOF capability. It would do so without adversely affecting U.S. test practices or programmatic planning. The U.S. STOF initiative does not address all possible avenues for developing this type of technology and, particularly, component tests in a non-system environment. However, the available alternatives to actual SLBM flight testing below 15 minutes would not engender the same high level of confidence provided by full-scale end-to-end testing. However, since the principal use of STOF capabilities would be as a "precursor weapon" in a preemptive attack, it may be unlikely that a cheater would accept lower reliability in a weapon that had not undergone a complete and overt flight test program which includes at-sea tests from a submerged SSBN. For these reasons, the U.S. STOF initiative constitutes an important confidence building measure which, if accepted, would enhance strategic stability.