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UNITED STATES ARMS CONTROL AND DISARMAMENT AGENCY
WASHINGTON

AUG 19 1963

Lloyd ATB

TO : General Counsel, Department of Defense, Mr. John McNaughton

FROM : ACDA - Mr. Adrian S. Fisher

SUBJECT : Verification of Compliance of the Nuclear Weapons Test Ban Treaty

It is clear that the recent signing of a three-media Test Ban Treaty and the likelihood that it will be ratified by the U.S. Senate make it imperative to consider U.S. plans for verifying compliance with the treaty. In accord with the statutory responsibility assigned to the Arms Control and Disarmament Agency "to formulate plans and make preparations for the establishment, operation, and funding of inspection and control systems which may become part of the United States arms control and disarmament activities . . .", ACDA wishes to express its views on this subject.

We expect that a major role in the detection of nuclear tests in the three media, underwater, atmosphere, and space, will be assumed by the Atomic Energy Detection System (AEDS) now operated by AFTAC for the purpose of detecting and following all nuclear developments outside the U.S. If so, AEDS will need to expand its test detection operations; a proposal to this end was submitted by AFTAC on 5 August 1963.

ARPA-VELA has responsibility for research and development relating to detection of high altitude and space tests as well as underground nuclear tests. Its role in the context of a test ban treaty must therefore also be considered.

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ACDA has worked closely with these two agencies in formulating its own ideas on verification. The National Detection System (NADES) that ACDA recently described to the Senate Subcommittee on Military Preparedness was developed by ACDA with close cooperation from both ARPA and AFTAC. The NADES system was intended for verification of a comprehensive test ban treaty and will need further consideration for fulfilling the verification requirements under a limited treaty.

It is useful to treat the media, underwater, atmosphere, and space, separately since different detection techniques are involved. Somewhat arbitrarily we shall consider tests at altitudes of from 0 to 50 kilometers as in the atmosphere and tests at higher altitudes as in space. In discussing these media and the third, underwater, it is convenient to do so by reference to the AFTAC proposal of 5 August.

Underwater -

Three techniques are available for detecting and identifying underwater nuclear bursts. These are seismic, hydroacoustic, and water sampling.

AFTAC proposes (and ACDA supports) one additional high quality seismic station in Scandinavia to improve coverage of the Soviet Union. To this ACDA would add encouragement that the US C&GS network of standard stations be upgraded wherever possible to provide adequate coverage of the southern hemisphere and open oceans.

The hydroacoustic technique is new to AEDS. AFTAC proposes a nineteen station network to cover the open oceans. This coverage should eliminate as possible clandestine explosions virtually all the earthquakes that occur in these vast regions. For those that cannot be identified in this manner, water sampling is applicable. ACDA recognizes the potential of this hydroacoustic network, but suggests the costs be weighed against the cost of routine surveillance of all Soviet bloc shipping capable of supporting a remote area effects test.

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Water sampling as a means of identifying underwater events in international waters or in bays and estuaries that diffuse into international waters is proposed by AFTAC and ACDA concurs. ACDA feels, however, that a capability such that it could obtain the requisite water samples within thirty days has a high enough probability of recovering radio-active debris that it would serve as an effective deterrent.

Atmosphere -

The atmospheric range of altitudes from 0 to 50 km deserves the greatest attention, because this is the region of most anticipated nuclear explosions in the event of hostilities, and therefore the pertinent region for the obtaining of effects information. Three principal techniques apply especially to this range of altitudes. These are acoustic, electromagnetic pulse, and debris collection. None of these are uniformly good over the whole altitude range, but only between 30 and 50 km does the combined capability deteriorate somewhat. This gap can be filled over particular suspected sites by backscatter radar or a specific VLF path. Satellite-borne sensors on the other hand seem to offer the promise of wide area coverage in this and other intermediate altitude ranges.

AFTAC proposes to double the AEDS acoustic network to provide adequate coverage of remote regions as well as the USSR and China. ACDA feels the relative importance of the latter region justifies more than the single addition to coverage of the USSR provided by a station in Scandinavia as proposed by AFTAC. A search for a quiet location in the Bering Sea region seems a particularly worthy endeavor. ACDA generally concurs in advocating the fifteen or so acoustic stations in remote regions, but feels that the priority for establishing these stations should be somewhat inversely related to the distance of the station from well travelled shipping lanes and non-communist land masses.

Although the electromagnetic pulse technique has a high false alarm rate, it is particularly applicable to the altitude range of greatest interest, i.e., 20 to 50 km. Therefore, ACDA concurs in AFTAC's proposal to increase the

EMP network by one more station in Asia and, if acoustic is also expanded into this region, ten stations in the southern hemisphere. Expected improvements in discriminating between lightning and nuclear explosions should improve the reliance which can be placed on this technique.

Debris collection is especially effective for nuclear bursts between 0 and 10 km. AFTAC contemplates daily sampling of the air masses moving out of the USSR. For detecting bursts at higher altitude, a balloon-borne gamma spectrometer or similarly a spectrometer mounted to look upward from a high-flying aircraft can be employed. These techniques and others are proposed by AFTAC. ACDA concurs in AFTAC's suggestions with respect to coverage of the USSR and China, and further concurs that monitoring of remote areas can be left to vectored sampling following some alert or particular suspicion.

Space -

The existing capability depends on ground based techniquess. The principal weakness is that the majority are effective generally over localized areas approximately within line of site. VLF phase anomaly is perhaps an exception, although the extent of coverage either side of the path between transmitter and receiver is rather limited for bursts in or below the ionosphere. For tests within the earth's magnetic field, the earth current technique virtually fills the gap. However, coverage of much of the earth's surface by two or more techniques requires wide deployment of installations.

Satellites, on the other hand, appear not to be so limited. Satellite-borne sensors could apparently police the test ban on a world-wide basis, covering the altitude range from about 30 km to millions of kilometers, even for low-yield detonations. The promise of this wide-spread coverage incident to the primary aim to extend detection and identification capabilities into interplanetary space carries with it the possibility of eliminating some of the surface-based sensors which would serve the same altitude region. Thus, in a system, satellites might add less net cost than their

own cost of $53 million per year estimated by AFTAC. ACDA advocates that a priority second only to atmospheric coverage over the USSR and China be assigned to evaluating this capability at an early date. If it is found feasible in time, it may permit deleting much of the augmentation of surface sensors for space tests before an investment has been committed to them. Even if it is only marginally useful, there is a strong potential for improvement (mainly in mean time to failure) and the mere existence of surveillance satellites in orbit provides evidence of our determination to police all environments and should deter contemplated clandestine tests in the associated range of altitude.

AFTAC proposes nine additional VLF receiving stations and an additional phase stabilized transmitter to improve coverage over the USSR and China. Sixteen more receiving stations are proposed to provide remote area coverage. ACDA concurs in the nine stations and the transmitter, but suggests that the extension of this system to the southern hemisphere might be deployed pending the evaluation of satellite systems. Substantial deterrent effect against tests in remote regions could be obtained by placing VLF receivers on board ships and thus achieving an unpredictable variable coverage.

delayed?

AFTAC proposes nine additional earth current stations to augment the ten now serving AEDS - ACDA concurs.

AFTAC's proposals to add atmospheric fluorescence stations, six in number, to provide a 70% or greater probability that two or more stations will be in view of a distant explosion, even allowing for cloud cover, is regarded as meritorious by ACDA. The combination of atmospheric fluorescence and VLF phase provide an interim capability against large tests in space which these additions improve. However, ACDA would assign distinctly lower priority to cosmic noise and vertical incidence. These techniques contribute redundancy which improves detection capability and improves the probability of identification, but these techniques are generally not independent of the other two, and thus the redundancy tends to be more a case of guarding against equipment failure than against anomalous phenomena.

Two other techniques are discussed by AFTAC, direct visible light and backscattering radar. Provision of the former capability at atmospheric fluorescence stations to increase the capability vis a vis shielded tests is proposed by AFTAC and ACDA would concur. Backscattering radar is described by AFTAC as of limited utility, and ACDA would agree, but point out the ability to react quickly to a new suspected site might argue to have an additional station in "mothballs" ready to install where appropriate.

It is expected that any new installation capable of carrying out meaningful effects tests will be picked up by conventional intelligence. Even if the suggestion regarding backscattering radar is not found practicable, the quick deployment of VLF receivers and cosmic noise stations at conjugate locations should be within the readiness capability of the verification system.

Summary of Comments on AEDS Augmentation -

In formulating positions on a verification system under a partial test ban, account has been taken of the sort of tests that might be carried out in space, in the atmosphere or underwater that could not be carried out underground. ACDA feels that worthwhile, sophisticated effects test operations will be very difficult to carry out in remote areas with any assurance of escaping detection. Therefore, spotty or random coverage by AEDS of many remote areas should suffice provided due attention is paid to other intelligence indicators. This contrasts with the AFTAC intent of providing coverage "as uniform as possible" over all remote areas and ranges of altitudes.

Generally ACDA concurs in AFTAC's recommendations with respect to improved coverage over the USSR and China and would in fact like to see further attention given to additional improvements in this coverage. Most other modifications suggested by ACDA tend to be in the direction of reduced emphasis or priority on remote area coverage. ACDA particularly expresses interest in the satellite capabilities, not only because of the extended coverage they might provide in deep space, but because they appear to fill in the

altitude range between atmospheric and very-high altitudes which otherwise can only be covered by extensive additional deployment of surface-based techniques.

VELA -

The verification system required under the limited test ban treaty must be supported with a continued research effort under project VELA. ACDA submits these general comments regarding the orientation and emphasis of the VELA program. First, it is essential that VELA become more systems-(as opposed to techniques-) oriented. Second, the altitude range between 0 and 20 kilometers should be considered specifically within VELA's purview. Third, the organizational separation between operations on the one hand and development on the other should be drawn more clearly.

ACDA further recommends the following specific suggestions be implemented through the various branches of the VELA program:

Ground Based Systems for the Detection of Atmospheric and Space Explosions -

Under VELA SIERRA it is recommended that the following projects be given a high priority:

1. New methods for improving the effective signal-to-noise ratio at acoustic stations should be studied and existing techniques should be refined.

2. Developmental work on the aircraft borne gamma ray spectrometer should receive all the effort that can efficiently be applied to it.

3. The balloon-borne spectrometer program should be funded with the objective of developing simple and reliable apparatus that can be flown from existing weather stations. In addition, background information should be obtained through a program in which flights are made at frequent intervals at several latitudes.

Satellite Based Detection Techniques and Deep Space Testing -

The VELA HOTEL program should continue as planned or perhaps be accelerated. A reassessment of the threat from deep-space testing should be made and its results incorporated into future VELA HOTEL activities. Also a serious study should be devoted to possible contributions which VELA HOTEL might make to the detection of explosions which occur at altitudes now policed by other techniques with a view to placing more dependence on the satellites.

Identification of Underwater Tests -

A rigorous study should be made of the problem of detecting debris from underwater tests. It appears that the most efficient way to identify an underwater event is to send a ship equipped with debris collection gear to the vicinity of a suspected event. The study should therefore consider debris transport, chemical concentration techniques, and logistics problems.

Underground Tests -

Although it appears that negotiating activities aimed at extending the partial test ban to include underground explosions will be at a low level in the near future, ACDA believes that certain objectives of the VELA UNIFORM program should be pursued at a more intense rate in order that the US be technically prepared for any revival of interest. Thus ACDA feels that the prime emphasis in the VELA UNIFORM program should be placed on identification of events at epicentral distances greater than 2500 kilometers.

It is further recommended that:

1. The manpower and equipment resources of the VELA UNIFORM field teams should be employed in the operation of novel types of arrays. (For example, the utility of arrays with dimensions on the order of hundreds of kilometers could be investigated. Also arrays might be set up in mines or caves.)

2. The effects on teleseismic signals of local geology both at the source and at the detector should be determined.

3. Arrays should be built in which three components of earth motion are recorded.

4. The possible utility of a three dimensional, three component array should be investigated.

5. Those studies which are concerned with the enhancement of the effective-signal-to-noise ratio through sophisticated data processing should be pursued with much more vigor than is now being done.

6. The program investigating the utility of ocean bottom instruments connected to land based recorders by long cables should be given a high priority. (Instruments of this type would be of extreme importance in locating events which occur in the Kamchatka-Kurile Island region.)

7. The magnitude-yield relationship should be better established and further study devoted to the problem of explaining the great spread in amplitude for a given event at a fixed distance.

8. The effect of the medium in which an underground explosion occurs on coupling should be better established.

Surely other worthy problems could be added to this list, some perhaps deserving a higher

priority than those listed. AEDA feels the important consideration is that past emphasis in the VELA program on developing hardware techniques has left open many feasibility questions.

Recommendations -

In accord with the suggestions and comments made above, the following general recommendations are submitted:

1. AEDS be augmented along the lines proposed in AFTAC memorandum of August 5, 1963, with modifications as brought out in the discussion above. Particularly, the satellite program should be accelerated, and the priority on remote area coverage of space kept low until the results from this program can be safely predicted.

2. VELA's research program be re-oriented to provide greater emphasis for the detection of underwater events, atmospheric events, and remote seismic events than is now accorded. High priority should continue to be given to satellite studies.

3. Provisions be made to insure that whatever group becomes responsible for verification of compliance with the test ban treaty shall be supplied with all related intelligence information including specifically all information on USSR ship movements and missile activity, as well as with the output of the AEDS.

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