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Comments Regarding

MONITORING AND SECURITY ASPECTS OF THE VERIFICATION PROTOCOLS FOR THE THRESHOLD TEST BAN TREATY (TTBT) AND THE PEACEFUL NUCLEAR EXPLOSIONS TREATY (PNET)

Submitted to
The Senate Select Committee on Intelligence

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In 1974 when the Threshold Test Ban Treaty (TTBT) was negotiated and signed, there was an uncertainty factor of two in the estimated yields of high-yield (greater than 20 kt) Soviet tests, as measured by National Technical Means with seismic stations outside the Soviet Union.[1] At that time, this level of accuracy was deemed adequate for verifying compliance with the TTBT, partly because nuclear warheads need not be tested at full yield for certification. Uncertainty in high-yield measurements using either hydrodynamic or seismic yield measurement methods (both are permitted under the treaty protocol) is on the order of 30 percent, or better. This improvement in accuracy is nice, but completely unnecessary for national security. No credible technical analysis has ever been presented to justify a requirement, on national security grounds, for this greater accuracy. Consequently, no useful purpose can be served by extensive Senate debate over the question of whether the protocol will achieve -- as I believe it will -- the degree of accuracy touted by proponents of the hydrodynamic yield measurement method.

Following the signing of the TTBT in 1974, analysts in the U.S. intelligence community argued that the Soviets were violating the treaty by deliberately testing over the 150 kt limit. The Reagan Administration even issued a finding that:

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[1] An uncertainty factor of two implies, for example, that given a measured yield of 150 kt, one can be 95 percent certain that the actual yield was between 75 and 300 kt.

> "Soviet nuclear testing activities for a number of tests constitute a likely violation of the legal obligations under the Threshold Test Ban Treaty."[2]

Overwhelming evidence reveals this conclusion as false. Yield estimates of Soviet tests that formed the basis for this claim were too high, due to inaccurate estimates in the seismic amplitude bias between the Soviet and U.S. test sites in Kazakh and Nevada, respectively. The evidence as of May 1988 has been summarized by the Office of Technology Assessment, which concluded:

> Extensive statistical studies have examined the distribution of estimated yields of explosions at Soviet test sites. **These studies have concluded that the Soviets are observing a yield limit consistent with compliance with the 150 kt limit of the Threshold Test Ban Treaty.**[3]

More recent evidence exists in classified analyses of (a) the 1988 nuclear test at Semipalatinsk that was part of the U.S./U.S.S.R. Joint Verification Experiment (JVE), whose yield was measured hydrodynamically and seismically; (b) five historical Soviet underground tests whose yields were revealed to the U.S. under the JVE protocol; and (c) the L_g wave amplitudes of several historical underground tests whose specific yields

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[2] "The President's Unclassified Report on Noncompliance with Arms Control Agreements," transmitted to the Congress Mar. 10, 1987.

[3] U.S. Congress, Office of Technical Assessment, "Seismic Verification of Nuclear Testing Treaties," OTA-ISC-361, (Washington, D.C.: U.S. Government Printing Office, May 1988), pp. 124-126.

have been published by the Soviets.[4] In sum, past performance offers absolutely no evidence that the Soviets would violate the 150 kt yield limit under the TTBT, nor the TTBT and PNET verification protocols.

The Reagan Administration's insistence on TTBT and PNET verification protocols permitting on-site hydrodynamic yield measurements was a successful political tactic intended to short-circuit public and Congressional momentum favoring a moratorium on testing and a comprehensive, or low-yield threshold, test ban. Strong evidence for this is found in a 1988 statement by Frank Gaffney, Deputy Assistant Secretary of Defense (Nuclear Forces and Arms Control Policy) during the Reagan Administration:

> The more time wasted on discussions and experimentation of [yield] monitoring techniques irrelevant to the verification of an environment in which there are no legal tests, the easier it will be to stave off demands for the more constraining comprehensive test ban.[5]

It will be a tragedy for America and the world if the Senate continues supporting this tactic by failing to promptly recommend ratification of these two treaties.

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[4] The date, time, location, and in 22 cases the exact yield, of 96 historical Soviet underground nuclear tests conducted between 1961 and 1972, were revealed in V.S. Bocharov, S.A. Zelentsov, and V.N. Mikhaylov, "The Characteristics of 96 Underground Nuclear Detonations at the Semipalatinsk Test Range," Atomic Energy, vol. 67, no. 3, September, 1989, pp. 210-214. (translated into English by the Library of Congress)

[5] Frank Gaffney, "Test Ban Would be Real Tremor to U.S. Security," Defense News, 5 September 1988, pp. 36-37.

In negotiating the TTBT and PNET verification protocols, and conducting the JVE, the U.S. and Soviet governments respectively favored the hydrodynamic and seismic yield measurement methods. The protocols allow for, and give equal weight to, both methods. In recent years several developments have strengthened the U.S. capability to measure yields of Soviet tests seismically. The most important developments include installation of in-country seismic stations in the Soviet Union, and recognition that uncertainty in estimates of the yield of nuclear tests can be substantially improved by utilizing L_g wave data.

Since 1986 the United States has operated seismic stations within the Soviet Union. Under a 25 May 1986 agreement between the Natural Resources Defense Council (NRDC) and the Soviet Academy of Sciences, three seismic stations were established around the Semipalatinsk test site in July - August 1986. The stations were jointly manned; personnel from the Institute of Physics of the Earth represented the Soviet Academy, while scientists from the Scripps Institution of Oceanography (University of California-San Diego) and the University of Nevada at Reno, worked on behalf of NRDC. Under a 25 June 1987 agreement between NRDC and the Academy, these three stations were relocated, beginning in 1988, and two additional stations were to be established. Four of the five of new stations, at Obninsk (OBN), Arti (ARU), Kislovodsk (KIV), and Garm (GAR), were

operating at the time of the JVE at Semipalatinsk on 14 September 1988. The fifth station at Irkutsk (YAK) is not yet operational.

In April 1988 the Eurasian Seismic Studies Program (ESSP), a joint U.S.-Soviet research program in seismology, was established with Incorporated Research Institutes for Seismology (IRIS) and the U.S. Geological Survey (USGS) representing the United States, and IPE representing the Soviet Union. This arrangement permitted the U.S. consortium (with Scripps as its principal contractor) to continue the joint program with IPE, using funding from the U.S. Government rather than NRDC. The U.S. component of the program is currently funded by Congress through an addition to the budget of the nuclear monitoring program of the Defense Advanced Research Projects Agency (DARPA). The program is carried out under Area IX of the Agreement on Cooperation in the Field of Environmental Protection.

Four ESSP stations (GAR, KIV, ARU, and OBN) are currently operational and data is being sent to the U.S. after processing at Obninsk. The stations will be upgraded with new high-frequency channels in August-September 1990. Additionally, two new stations, at Talaya (TAL) and Ala-Archa (AAK), will be installed, bringing the total number of in-country stations to six. A seventh station at Garni (GNI) is scheduled for late 1990, and six additional stations have been approved for 1991, including one at Novosibirsk (NVS). The ESSP scientists

anticipate that six additional stations will be approved next year for the Soviet Union, bringing the total to 19 stations. In the region of two of the stations, Garni (GNI) in Armenia and Ala-Archa (AAK) in Kirghizia, about 10 additional surface stations will be installed to form two arrays covering about 10,000 square kilometers each. The Kirghizia network will also include a tight array similar to the Norwegian Regional Seismic Array (NORESS), established by the U.S. and Norway in 1984.

The TTBT verification protocol designates Arti (ARU), Obninsk (OBN), and Novosibirsk (NVS) have been designated as the seismic stations to be used by the U.S. to conduct seismic yield measurements. But in fact, under the ESSP program the U.S. will receive seismic data from many more stations in the Soviet Union. Furthermore, these stations will operate during all Soviet tests, not just the high yield tests designated under the protocol. The cost of establishing and operating this network for a year is a fraction of the cost of a single hydrodynamic measurement in the Soviet Union.

Another recent, significant breakthrough in yield estimation using the seismic method derives from studies begun in 1985 indicating that the accuracy of yield estimates can be improved through utilization of L_g wave data.[6] The L_g wave is a type of

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[6] A more thorough review of the L_g wave and new information on

(continued...)

guided wave, composed of numerous seismic waves trapped between the earth's surface and the earth's crust/mantle boundary. At distances below a few thousand kilometers the L_g wave amplitude is larger than the body and surface wave amplitudes traditionally used for yield estimation. At greater distances, the signal is typically too weak to be of much use. Hence, for the purpose of estimating the yields of Soviet tests, the use of L_g waves data is limited to cases where the seismic stations are within or near the Soviet border.

To maximize the utility of L_g wave data for measuring Soviet test yields, the relationship between the amplitude of the L_g wave and the yield of Soviet tests must be established. This involves using recorded L_g signals from previous Soviet tests where specific yields have been disclosed. This has been done for at least ten tests at Semipalatinsk, namely (as mentioned above), the five whose yields were exchanged under the JVE protocol, the JVE test itself, and four tests whose specific yields were published by the Soviets.[7] These data demonstrate that when regional L_g data is included, uncertainty in the

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[6](...continued)
Soviet yields can be found in publications by Paul G. Richards and Lynn R. Sykes of Columbia university. Much of the discussion here derives from early drafts of their book Verification of Limits on Nuclear Testing: A Review of Historical, Technical and Political Review, (in preparation).

[7] V.S. Bocharov, et al., op. cit.

seismic yield estimate is on the order of 15 percent -- comparable to, if not better than, the accuracy achievable using the hydrodynamic method. Furthermore, this seismic yield measurement capability was established independently of the TTBT protocol. It will be operational for all Soviet tests, and is dramatically less expensive than the hydrodynamic method. These in-country seismic stations, coupled with the hydrodynamic method, represent a U.S. capability to monitor Soviet test yields greatly exceeding our national security needs.

The strong public opposition to testing which has developed in the Kazakh Republic makes further testing at Semipalatinsk unlikely. Future Soviet nuclear tests will probably be restricted to the arctic site at Novaya Zemlya -- a site for which the U.S. has limited seismic data from nuclear tests. The site is closer than the Semipalatinsk site to NORESS. Relative to the Semipalatinsk site, geology and seismic paths for P and S body waves from Novaya Zemlya are well understood. Thus, the seismic yield estimates (based on analyses of body wave data) for tests at Novaya Zemlya have smaller uncertainties than similar seismic (body wave) estimates for tests at Semipalatinsk. On the other hand, no L_g wave data exists yet from ESSP in-country stations for tests at Novaya Zemlya. It is not even known whether ARU, OBN, and NVS -- the three stations designated in the Soviet TTBT protocol -- will provide L_g wave data for Novaya Zemlya at a signal-to-noise ratio of nine as specified in the

protocol. Some of the future ESSP stations will be located closer to Novaya Zemlya; and hopefully with a few hydrodynamic yield measurements for calibration, they could provide yield estimates with uncertainties comparable to the uncertainties currently being obtained for tests at Semipalatinsk.

The yields of the five historical U.S. and Soviet tests which were exchanged under the provisions of the JVE, and the results of the JVE itself, remain classified by the Administration despite the fact that JVE protocol permits release of these data if both parties agree, and despite the fact that the Soviets do not object to their release. The Administration's failure to negotiate with the Soviet government for release of this data hampers independent research on nuclear testing verification, and prevents full debate on the merits of the TTBT protocol and future test-limiting treaties, e.g., a low-threshold or comprehensive test ban treaty. Section XII of the TTBT and PNET protocols permits the Administration to withhold from public disclosure much of the information obtained in accordance with the TTBT and PNET protocols, either by classifying the U.S. data which is shared with the Soviets, or by failure to seek Soviet permission to release information that cannot be released without mutual agreement. In its deliberations the Senate should obtain assurances that the Administration will make every effort to maximize the amount of information released to the public

regarding measurement of yields by seismic and hydrodynamic methods.

In sum, NRDC supports prompt ratification of the TTBT and PNET. In its deliberations the Senate should demand assurances from the Administration that it will release, seeking permission from the Soviets when necessary, all information collected in accordance with the TTBT and PNET protocols, and the JVE. Finally, in its normal budget cycle the Senate should insure that adequate funding is provided to the Eurasian Seismic Studies Program to permit continued operation and expansion of its seismic network in the Soviet Union.