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Verification Aspects of a Comprehensive Test Ban Treaty (CTBT)

Introduction

1. A comprehensive test ban was originally conceived as one step on the path to general and complete disarmament. But the main impetus for opening formal negotiations in the 1950s came from concern over the possible biological effects of fallout from large scale testing of nuclear weapons in the atmosphere. The conclusion in 1963 of a Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water (PTBT) largely dispelled this concern. Testing of nuclear weapons has, however, continued underground. A serious obstacle to the conclusion of a comprehensive treaty has been agreement on acceptable methods of verification which would also cover that environment.

2. An adequate verification system has to provide an assurance that the treaty is being complied with by all States Parties. If it does not, the treaty will not attract wide adherence since some States will consider that it poses unacceptable risks to their security. Second, a verification system subject to wide error would generate a lack of confidence which could lead to accusations of breaches of the treaty even when it was in fact being wholly respected. Such accusations could have damaging consequences on international relations.

3. Despite the impression created by some commentators, the verification of a comprehensive treaty would pose difficult technical problems, especially in respect of monitoring the underground environment. This is not to say the verification technologies available for the environments prohibited by the PTBT would necessarily be adequate if a comprehensive treaty were in force. The security risks which might follow if States Parties failed to comply with the PTBT are small because the testing needed to maintain the viability of existing weapon stockpiles and nuclear weapon systems can legitimately take place underground. There is little incentive to test in the prohibited environments; even if testing did take place in such environments instead of underground, the consequences for military balances are unlikely to be serious, even though a breach of the Treaty would have great political significance. If, however, a comprehensive treaty were in force, there would no longer be a legitimate route for continued testing, and if a State decided to evade its obligations it would select that environment for testing which offered the best chance of escaping detection. The need for further measures of monitoring of these other environments cannot therefore be dismissed without consideration.

Seismic Verification

4. The major problem in verification of an NTB is however undoubtedly connected with underground testing, methods for which have been highly developed over the last 20 years. Much effort has been devoted to the technology of monitoring the underground environment. But there have been no outstanding technical breakthroughs and reliance still has to be placed on seismic means of detecting and identifying underground events. No other methods promise to provide a way of obtaining information about underground explosions at long ranges - and long range systems are an essential element in any realizable verification arrangement.

5. There is general agreement within the informed scientific community (as the work of the Ad Hoc Group of Scientific Experts set up by the Committee on Disarmament shows) that available seismic methods allow seismic events with body wave magnitudes of about 4 or more to be detected with a high (say 90 per cent) probability. The threshold of detection is set by the earth's natural seismicity. But detection of a signal without being able to identify whether it was caused by an earthquake or an explosion is of little value for the purpose of verifying compliance with a comprehensive test ban treaty. Indeed detection of an event without being able to identify it could be disadvantageous, because it could give rise to false suspicions of non-compliance with the Treaty. In any case, because earthquakes of significant magnitude occur relatively frequently, a monitoring system which could not distinguish them from nuclear explosions would rapidly be overloaded by earthquake signals. Thus it is of crucial importance to recognize that what is important from the point of view of verification is not detection alone but detection and identification, the threshold of which is about half a magnitude higher than for detection alone. (It is conceivable that further work in this area could provide, at some time in the future, for a similar probability level at a marginally lower figure of body wave magnitude). Failure to recognize this fact can give rise to over-optimistic assessment of the ability of the proposed world-wide seismic network.

6. There is less unanimity in the scientific community about the relationship between the magnitude of a seismic signal and the yield of nuclear explosion which produced it. Extensive studies by United Kingdom scientists have shown that a seismic signal of magnitude 4½ can be related to about a 3 kiloton explosion which is close coupled with surrounding hard or water saturated rock. 1/ For explosions in close contact with dry and soft rock in a stratum of sufficient

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1/ In CCD/492 (April, 1976), a magnitude of 4½ was rounded up to equate to 5 kilotons but the 3 kilotons figure given here is more accurate.

thickness, a seismic magnitude of 4½ equates to a yield of about 30 kilotons. And, for explosions detonated in a sufficiently large cavity in a geologic formation (assuming that the formation is able to support a large cavity) a seismic magnitude of 4½ equates to a yield of up to 300 kilotons. Thus the detection and identification threshold currently achievable in theory by seismic means can be associated with explosive yields from about 3 kilotons to up to 300 kilotons.

7. Some of those who believe that existing methods of verification are already adequate tend to base their assessment on the assumption that clandestine testing would invariably be carried out with close coupling in hard rock and at sites already used routinely for nuclear testing. Where they do recognize that other possibilities exist, they tend to assume that sites suitable for close coupled tests in soft dry rock would not be available and that decoupled tests would not be practicable. Neither of these assumptions is valid except perhaps in relation to the practical problems of constructing a cavity large enough to decouple an explosion of say 100 kilotons or more. Our broad assessment is that decoupling offers the possibility of conducting nuclear weapon tests of up to a few tens of kilotons without producing seismic signals in excess of the detection and identification threshold of magnitude 4½. Any nuclear weapon State which was able to test up to a level of a few tens of kilotons in undetected breach of a comprehensive treaty would realize a very significant advantage.

8. The Ad Hoc Group of Scientific Experts has reported that the achievement of a detection and identification threshold of seismic magnitude 4½ requires the services of a global network of high quality seismic stations. The Group has, however, not been asked to consider the arrangements that would be necessary to ensure that these stations produced reliable seismic data of adequate quality and on a sufficiently fast time-scale. In so far as the Group has discussed the

quality of data, they have found significant differences of view on what is necessary. Equally strong differences would be found on the means of ensuring that data were reliable and timely. Contrary to the opinions of some commentators, the establishment of a global network in which all Parties to a comprehensive treaty would have confidence poses many difficulties. This is especially true for those stations of the network which would be crucial for monitoring those countries with large land masses.

9. There are two other possible methods of evasion that should be considered. First, the criteria for differentiating between explosion and earthquake seismic signals are sufficient only if the seismic signals have a reasonable signal/noise ratio. This ratio could theoretically be depressed for an explosion signal by timing the explosion so that it coincided with the signal produced by a nearby earthquake. Any attempt to hide an explosion in an earthquake signal would be very constraining, both in time and place, on the nuclear test. But it cannot be ruled out as a possible method of evasion if the incentive for a clandestine test were sufficiently great. Second, the purposes of a CTBT would be completely undermined if the Treaty did not prohibit the conduct of so-called Peaceful Nuclear Explosions (PNE) which could be used to derive information of direct nuclear weapons value. So far, as demonstrated in an earlier United Kingdom paper on the subject tabled as CD/383, there have been no verification proposals which offer the prospect of agreement being reached on measures which would allow a PNE as part of a CTBT.

10. The discussion so far relates to verification capabilities theoretically achievable with a global seismic network of the type considered by the Ad Hoc Group of Scientific Experts but expanded somewhat to provide better coverage of the Southern Hemisphere. This would detect about 50,000 earthquakes at or above body-wave magnitude 4 each year and clearly would need to be furnished with a data transmission and signal processing system of high capacity and complexity. A global network does not, however, cater specifically for monitoring Treaty compliance within the boundaries of States with very large land areas.

11. It has previously been suggested that, for these special cases, enhanced confidence in Treaty compliance would be obtainable if the density of seismic stations within such countries were increased above the global average. It would be politically unacceptable, technically difficult and economically expensive to have a high enough density of seismic stations to make a significant reduction in the detection and identification threshold for all seismic events occurring within these large countries. The additional stations should perhaps be primarily regarded as offering the capability of monitoring more closely those areas within a large country where it might be technically feasible to implement measures for evading detection and identification by the regular global network. The possibilities of exploiting the data available from these regional stations for CTBT monitoring - especially data recorded at relatively close range from an event as opposed to data acquired at teleseismic distances - deserves more study. Obviously data from regional stations specifically installed to monitor events within the region would have to be authenticated more rigorously than data from the global network.

12. A limitation of all assessments of seismic verification capabilities is that almost all the underground explosions, from which seismic data have been recorded, have been carried out in areas of low seismic activity. Thus the transmission paths for the seismic waves from explosions to the detection stations have been geographically different from those for earthquake seismic signals. Consequently there must be some uncertainty about the verification capability of a seismic station network operating against underground explosions conducted in an area of high seismic activity.

On-site Inspection

13. No matter how good seismic verification of a comprehensive test ban treaty might be, the interpretation of seismic signals can never give completely conclusive proof that a nuclear explosion has taken place. There would always be the possibility of dispute; and there is in any case, no method of differentiating seismically between a nuclear explosion and an explosion of any other type. This last point is not trivial because there have been conventional explosions with yields in the sub-kiloton and very low kiloton range.

14. An almost unambiguous indicator of a nuclear explosion is the presence of fission products but, for an explosion conducted underground with complete containment, these fission products will be retained within the cavity formed

by the explosion. There is no known way of detecting their existence at a distance. However, if an underground nuclear explosion had been carried out, there would be some signs which could be looked for at the actual site. Greater confidence in the effectiveness of verification would therefore be obtained through arrangements which permitted inspections of the sites where there is evidence that a clandestine explosion may have been carried out.

15. The negotiation of arrangements for on-site inspections raises many difficulties, because such inspections are seen as potential infringements of national rights and as potentially prejudicial to national security. Nevertheless verification arrangements would be regarded as unsatisfactory if they did not provide for on-site inspections on terms and under conditions acceptable to all Parties.

The Implications of a Detection/Identification Threshold

16. The fact that physical factors impose a threshold below which it is not possible to verify an NTB would be significant if testing below the threshold could serve a useful nuclear weapons purpose. It is the case that operational requirements for theatre nuclear weapons may call for yields of the order of 10 kilotons; such weapons could clearly be tested at full yield within a verification threshold of some tens of kilotons. But low yield tests could also be used to prove the fission triggers which are used to initiate further nuclear reactions in high yield nuclear weapons. Although some progress has been made with the development of mathematical modelling and non-nuclear experimentation for assessing the behaviour of trigger designs, a final judgement on design integrity can be made only on the basis of results from nuclear testing, which, for this purpose, can be conducted at a yield level of the order of 10 kilotons. It follows, therefore, that an ability to test at this yield level is of importance in respect both of maintaining existing weapons stockpiles in the face of aging effects and of developing new warhead designs. This example is not unique. Other types of test at the 10 kiloton level would be equally important and all of them would serve to maintain the competence of weapon designers and confidence in their advice.

Conclusions

17. A worldwide system of seismic stations as proposed by the Ad Hoc Group of Scientific Experts working to full capacity would permit seismic events of body wave magnitude of $4\frac{1}{2}$ or more, to be detected and identified as coming from natural events or from explosions. This capability would, in the United Kingdom's view, not rule out the possibility of clandestine tests of nuclear weapons being carried out underground at yields up to a few tons of kilotons. These tests could have considerable military significance.

18. Unless significant improvements can be made to presently available verification techniques, a gap will remain which could be exploited to affect significantly the balance between nuclear weapon States. This conclusion runs counter to some commonly held views which may be based on assumptions about the realizability of an effective global network which are at the moment unjustified. It is doubtful whether some published assessments attach proper weight to various technical factors; in particular, some fail adequately to differentiate between detection alone and detection and identification.

19. Difficult problems remain with respect to on-site inspection which have yet to be solved. Further, there is no agreement on whether or not it is possible to accommodate arrangements for nuclear explosions for peaceful purposes with a comprehensive test ban treaty. These difficulties formed an important part of the trilateral negotiations between 1977 and 1980, and were clearly identified in the report to the CD on those negotiations (Document CD/130). But the work done in the Committee on Disarmament since 1982, particularly by the Ad Hoc Group of Scientific Experts, has been valuable in identifying areas where further progress might be possible. What is at issue is the political will to recognize that the correct path towards an agreed treaty - however long it may prove to be - leads through detailed consideration of the verification issues. Once we are confident that those problems have been resolved - and the solution must not permit disequilibrium in international relationships by allowing one side to gain advantage over another - then we can move towards the final banning of all nuclear tests.