ANNALI DI GEOFISICA, VOL. XXXVII, N. 3, June 1994

On-site inspection for nuclear test ban verification

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Abstract
The problem of verifying compliance with a nuclear test ban treaty is mainly a technical one. However the problem of detecting, locating and identifying nuclear explosions has, since the late 1950s, been intimately involved with the political problems associated with negotiating a treaty. In fact there are few other areas in which policy, diplomacy and science have been so interwoven. This paper attempts to illustrate how technology can be applied to solve some of the political problems which arise when considering the role of an On-Site-Inspection (OSI) to determine whether or not a nuclear explosion, in violation of a treaty, has occurred or not. It is hoped that the reader, with a scientific background, but with little or no experience of treaty negotiations, will gain an insight as to how technical matters can interact with political requirements. The demands made on scientists to provide technical support for negotiating and monitoring compliance of a treaty have increased significantly over the last 40 years. This is a period in which a number of major treaties have contained a significant technical component *e.g.* the Limited Test Ban Treaty (Threshold Treaty) and the Chemical Weapon Convention. This paper gives an indication of some of the political decisions which will have to be made and suggests some of the technical methods which are of value in the identification of a clandestine nuclear explosion.

Key words *on-site inspection – nuclear test ban*

1. Introduction

The technical verification of compliance with the provisions of a treaty banning all nuclear weapon test explosives – a Comprehensive Test Ban Treaty (CTBT) – would have to be primarily by long-range sensors. For the underground environment (generally agreed to be the most difficult environment to monitor), the verification system would, most importantly, have to include a network of teleseismic and regional seismic stations; the former would be sited to provide global coverage, and the latter would be positioned to provide local supporting information from specific areas.

There may be differences of opinion about how effectively a given network of seismic stations would monitor compliance with a CTBT but few would agree that there would not be instances where it would be difficult to detect and/or identify a seismic signal. Even with an extensive seismic network, signals from small underground nuclear explosions (especially if conducted in an underground cavity) detected with low signal/noise ratios might not be identifiable.

Test ban monitoring must be highly efficient. Otherwise there could be frequent, possibly damaging, disputes over seismic events which suggested possible non-compliance, and national security interests could be prejudiced. It would be essential to have additional means of verification to deal with events not identifiable with confi-

dence by seismic systems. For such events, it has been suggested that on-site inspections might supply at least a partial answer. The purpose of this paper is to discuss on-site inspection as an element of a CTBT verification system.

There is a number of issues that deserve attention:

a) Would a CTBT provide mandatory rights for short notice on-site inspection?

b) What conditions would have to be fulfilled before an on-site inspection could take place?

c) Who would conduct an inspection: national inspectors or multinational teams? What role could the inspected party play?

d) What would be the composition and equipment of the team of inspectors?

e) What would be the timing factors in mounting and carrying out an inspection?

f) How would the inspecting team travel to and be assured of arriving at the area nominated for inspection?

g) What would be the rights and functions of the Host country representatives and of the members of the inspection team on arrival in the Host country and at the inspection site?

2. The need for short notice challenge inspections

It is recognised that on-site inspections have a role to play in Treaty verification. The Treaty on Conventional Armed Forces in Europe (1990), the Chemical Weapons Convention (CWC) (1993) and both have extensive provisions for routine and challenge inspections.

With current detection technology a state which conducted a clandestine nuclear test would have to presume that an on-site inspection team would be able to establish whether or not an illegal explosion had indeed been carried out. It is likely that such states would therefore refuse access to inspection facilities which might produce evidence of a breach of the Treaty. Thus it is possible that on-site inspections would never be permitted to produce evidence of illegal tests. Nevertheless, they have an important role to play in deterring illegal tests and building confidence in a CTBT. Any regime for on-site inspections must be one which places the onus for refusing an inspection on the suspect party while permitting innocent states to co-operate in clearing up uncertainty.

A mandatory on-site inspection regime would be most effective in this respect. A would-be violator would know that he would be faced with a demand for an on-site inspection should his planned clandestine explosion give rise to any suspicion. In refusing to allow a mandatory inspection – as he would be almost bound to do – the violator would be in direct breach of the Treaty obligation and would, thereby, give indisputable cause for other Treaty Parties to trigger whatever sanctions provisions the Treaty might contain.

But the problem of defining criteria in the mandatory inspection context, which is discussed later, might mean that an inspection procedure might have to be adopted that allowed both the Party or Parties requesting an inspection and the «suspect» Party to put forward evidence to support their cases. The Party which suspected that an illegal nuclear test had been carried out could be required to produce evidence to justify a request for an on-site inspection. And the «suspected» Party would have an opportunity of showing why the suspicions levelled against it were unjustified. Evidence of any type should be accepted for consideration, and it might be preferable if it were presented in an international forum, where it could be assessed whether the case for an inspection was sufficiently strong. At this stage an international organisation would clearly be best placed to provide as objective an assessment as possible. The aim would be to ensure all Treaty Parties would be in a position to judge the reasonableness or otherwise of any refusal of the

inspection request, and the validity of any reaction by the challenging party to such a refusal.

3. Criteria for initiating an on-site inspection

However it would be wrong to expect that a Treaty would ever provide carte blanche for on-site inspections. Under any inspection system, every Party to a CTBT would require some constraints to be placed on the freedom with which other Parties could initiate and conduct inspections, otherwise on-site inspections could be improperly mounted for purposes not connected with test ban verification. In other words, unconstrained inspections could infringe national sovereignty and security. A balance must, therefore, be struck between the legitimate verification interests of Parties requesting an inspection, and the sovereignty and security interests of the Party on whose territory the inspection would be carried out. It is worth recalling that the CWC has been able to strike a balance between these two objectives, and this is reflected in the CWC Implementation and Verification Annex.

As well as inspections initiated on the basis of evidence of a test having been carried out, it would have to be considered whether an inspection could be requested on the basis of evidence of preparations for a test. If criteria for inspections to be initiated in this way could be agreed, it might be possible to increase the chances of upholding a test ban regime by preventing a test being conducted.

The criteria to be satisfied before a mandatory right of inspection could be exercised would be difficult to define. With present knowledge, the detection of a possible clandestine nuclear test is most likely to be obtained by seismic means but, as yet, the effectiveness of methods differentiating between seismic signals from underground nuclear explosion and seismic signals from earthquakes (and from human activities other than nuclear testing) is not universally agreed.

For a particular seismic signal, some might categorise it to be of explosive origin, others of earthquake origin, and yet others might not be able to classify its origin at all. In addition, teleseismic signals are available from only a relatively small number of sites; regional seismic signals are in even scarcer supply. Although it is possible to extrapolate from known seismic data to predict what might be recorded at other locations from tests away from existing sites, the history of test ban verification research is littered with examples of erroneous extrapolations. For these reasons it is not possible at present to generate a universally acceptable set of criteria to be satisfied by a seismic signal before an on-site inspection could be demanded. Even if an acceptable set of criteria could be developed, there would remain a potentially damaging suspicion that a clandestine explosion might generate seismic signals which failed to meet the criteria for an inspection demand.

Doubts about Treaty compliance might also arise from other means of monitoring. For instance, satellite surveillance could detect ground-based activities which appeared consistent with an underground nuclear test operation. However it would be difficult to specify the characteristics required of satellite observations that constituted prima facie evidence of a clandestine nuclear test or preparations for one. There could be yet other sources of intelligence about possible nuclear testing which would be equally difficult to define in advance.

4. National or multinational inspections? What role could the inspected party play?

Inspections of a suspect party could be carried out by one or more of the other states parties who believed there were grounds for an inspection. Or they might be conducted by an organisation acting on

behalf of states parties. In this case a new organisation comparable to the IAEA, say, might need to be established. And within the second approach, the organisation could itself be responsible for initiating inspections, or the initiative could come from nations, leaving it to the organisation only to conduct an inspection and report findings.

It must also be considered to what extent the inspected party could participate in an inspection. On the one hand, the need for the inspection might have arisen because one Treaty Party suspected non-compliance on the part of another. This situation could not have come about if there were sufficient trust between the two Parties concerned and argues for inspections to be controlled by the team carrying it out. The inspected Party's formal role would then be to monitor the actions of the inspectors to ensure that they do not transgress previously agreed rules for the conduct of the operation. Such a basic regime would minimise the opportunities for the «suspected» Party to frustrate the aims of the inspection.

On the other hand, there is a wide recognition that test ban monitoring – particularly seismic monitoring of low magnitude sources – is prone to produce false indications of underground explosions, and that false indications, if not satisfactorily identified as such, would undermine confidence in a test ban regime. Consequently, it would be in the interests of all Parties, including the Party from whose territory the false signals had been obtained, to explain their origins and establish their «innocence». Therefore, the «suspected» Party could claim that it had as great an incentive as the «suspecting» Party to investigate the «suspicious» event and that both should cooperate in seeking an explanation. Confidence in a test ban regime might therefore be enhanced if the inspected party can participate to a sufficient degree in the inspection to help eliminate uncertainty, while not having the opportunity to frustrate its purposes, and leaving the inspection team properly in control.

5. Size of inspection teams and their equipment

Any protocol for on-site inspections would have to define the maximum number of inspection personnel to be allowed and the types of equipment that could be imported for their use. Clearly, it would be desirable to have sufficient inspectors so that the work could be carried out efficiently and expeditiously. However, it would be an intolerable burden on the Host Party to have to monitor the activities of an excessive number of inspectors. To keep the numbers down therefore, it would be desirable for the support personnel for the operation, *e.g.* those for transport, accommodation and feeding to be provided by the Host Party. The size of the inspection team would be determined in the light of the types of investigations to be carried out but it is likely to lie between, say 10 and 50 investigators. Suitable and readily available instrumentation for on-site inspection is limited, and while each individually may not be able to provide conclusive evidence, collectively they have the capacity to add substantially to confidence in a Treaty regime. The principal technical approaches are as follows.

6. Monitoring for radioactivity

Critical evidence that an underground nuclear explosion had taken place in a given area would be provided by the collection of radioactive debris from the explosion. Such debris could be analysed to prove whether or not it could have come from a nuclear explosion and, if so, information about the explosion – including an estimate of the time at which it had occurred – could be derived. Unfortunately, the chances of being able to collect debris are, in reality small. The only sure way

would be to locate the underground cavity containing the debris – the cavity produced by the explosion or the cavity in which the explosion had been carried out – and to drill into it so that its contents could be sampled. To locate a small cavity at depth within the Earth is not a trivial task. It is possible that efforts designed to contain the explosion would prove to be faulty and could have allowed some gaseous debris to leak out (perhaps the most useful diagnostic product from a nuclear explosion is the gas Krypton 85. If Xenon 133 (a short-lived isotope) can be detected along with Krypton it will indicate that the isotopes are of relatively recent origin). If the inspection took place sufficiently soon after the explosion, and in the immediate area of the explosion, this debris might be collected and measured. Hence, radioactive measuring equipment should be included in the investigators' inventory. Little weight would, however, be placed on negative readings from such equipment.

7. Visual examination

The most potent on-site inspection technique is probably a straightforward visual examination of the suspect area to see whether there was any equipment suggestive of a nuclear test operation or signs of some other activity which could have provoked the original suspicion of an underground explosion. For example, an inefficiently conducted nuclear test could cause a subsidence crater to appear on the Earth's surface as a result of an unexpected collapse of the underground cavity. This consequence certainly could not, however, be relied upon. The visual inspection would be assisted by optical equipment, *e.g.* surveying instruments, cameras, etc., and by the use of metal detection equipment, all of which should be available to the inspectors.

8. Local seismic monitoring

Following an underground nuclear explosion, it is to be expected that microseismic activity will persist for some time, possibly for some weeks in the vicinity of the explosion cavity, until the area returns to a stable condition.

This would however depend on a number of factors including the yield of the explosion. It should be possible to detect and locate this activity with a small number of seismometers distributed in the area in which the explosion is thought to have occurred.

The Parties to a Treaty would need to reach prior agreement on how the responsibilities for supplying equipment for inspection purposes should be divided between the Host and Challenging Parties. This will require a compromise to be struck between the interests of the Host – which would probably prefer to be totally responsible for equipment supply, in order to avoid offering opportunities for the import of equipment for capabilities not sanctioned by the inspection arrangements, and those of the Inspectors – who would probably prefer to use their own national equipment, with which they would be familiar and in whose characteristics they would have confidence. Whatever the compromise, it does not appear to be unduly difficult to devise procedures which would protect the lawful interests of both the Host and Challenging Parties.

9. Timing

If on-site inspections were to serve the aim of confidence-building, they must take place quickly. Any sign of deliberate delaying tactics by the Party on whose territory a suspicious event had occurred would probably be read as an attempt to reduce the chance of inspectors discovering evidence of Treaty non-compliance. The after-effects of an explosion would certainly decay with time: the longer the interval between a suspected explosion and an inspection, the greater would be the opportunity for removing any tell-tale evidence. In any case, stalling tactics might be seen to be a way of

postponing an announcement that facilities for an inspection would not be allowed.

Time limits should therefore be specified in the on-site inspection procedures. There would inevitably be an interval between an announcement, in some forum, that a suspected Treaty violation called for an on-site inspection and the time at which the inspection team would be able to reach the area of concern. An interval in the order of 5 days might be appropriate, but the precise timing would have to be negotiated by reference to the period of time over which one could expect to detect physical effects generated by low yield explosions which would present the greatest verification challenge.

It is difficult to estimate how many days would be adequate for an on-site inspection. This is partly because the size of the area in which the suspicious event had occurred cannot be defined in general terms and partly because the nature of the area to be inspected could vary greatly. The area to be inspected would depend on the accuracy with which the suspicious event could be located and, assuming that the event had become known through the detection of a low signal/noise ratio seismic signal, it might not be possible to determine its epicentre to an accuracy of better than a few hundreds of square kilometres. In this case, a fairly large area would have to be surveyed, possibly by aerial photo-reconnaissance over a period of a few days, before the inspection site could be selected. It is not inconceivable that this preliminary survey would fail to identify a unique area for ground inspection and a decision would have to be taken on whether to inspect a number of areas – the procedures should cater for this possibility – or abandon the inspection. Ideally, the procedures defining the duration of the inspection should be flexible but, given the risk that the Host and Challenging Parties would fail to reach agreement on the timing for a specific inspection, it might be more satisfactory to fix a duration at, say, a maximum of about 40 days. Much, however, would depend on the context of the individual inspection.

10. Travel to the inspection site and aerial reconnaissance

It would seem to be most efficient, and consistent with recent arms control precedent, if the inspection teams were made responsible for its own travel arrangements from its home base to a nominated port-of-entry in the Host country and if the Host country were made responsible for transporting the inspection team from this port-of-entry to the inspection area. Such an arrangement could, however, give rise to a problem unless the inspection team were authorised to perform an independent navigational check on the place to where they were taken so that they could be sure that they were in the area they were required to inspect. There would be a requirement for the inspection team to have access to their own navigation systems, like GPS, for this purpose.

The Open Skies Treaty provides a good model for the co-operative conduct of aerial photo-reconnaissance flights, if they are required.

11. Rights and functions of the Host and Challenging Parties

The rights and functions of the representatives of the Host and Challenging Parties would have to be defined so that the former would be able to protect the legitimate sovereignty and security interests of the Host country and so that the latter would be able to undertake their legitimate inspection activities. The CWC's managed access provisions provide a useful model. As noted above, these strike a balance between the need for instrusive inspection and the Parties' rights to protect sensitive information unconnected to chemical weapons. If these definitions were not drawn up precisely, there could be scope during an inspection for disputes over what could or could not be done; and such disputes could undermine the confidence-

building purposes an on-site inspection is intended to serve.

The protocol dealing with rights and functions would need, *inter alia*, to define:

a) the status of the inspectors whilst on the territory of the Host nation; *e.g.* diplomatic status, rights of access, etc.;

b) the equipment which the inspectors would be authorised to import into the Host country;

c) the division of responsibilities and costs for meeting the transport requirements of the inspectors between the port-of-entry and the inspection site and within the inspection site;

d) the responsibilities for the conduct of the initial surveillance of the general area within which the inspection would take place;

e) the activities which the inspectors would be authorised to undertake at the inspection site and the assistance they could obtain from the Host country for their inspection tasks;

f) the facilities available to the inspectors for communicating with their own Government during the course of the inspection;

g) the rights of the representatives of the Host country to have access to the results obtained during an inspection;

h) the procedure for dealing with any disputes arising during an inspection.

Many of these issues have been touched upon earlier on in this presentation, and indeed the procedures for dealing with some of these practical issues have already been agreed for other arms control Treaties.

12. Conclusions

Arrangements for on-site inspections would constitute an essential element of any verification regime for a CTBT. The willingness of the Parties to accept realistic on-site procedures would, of itself, be a confidence-building measure. After a Treaty had come into force, the existence of these procedures would serve as a deterrent to cheating, even though there could be no confident expectation of an inspection team being given direct access to the site of an actual clandestine explosion. Successful on-site inspections of false indications of a clandestine explosion, *i.e.* inspections which had proceeded smoothly in accordance with pre-determined procedures, would reinforce confidence in Treaty compliance. The requirements for a successful on-site inspection regime are likely to be demanding. But they are by no means excessive when compared with the procedures which have been agreed in the many arms control negotiations which have been concluded over recent years.