APPENDIX 1

THE EFFICACY OF EFFLUENT DETECTION BY WIDE-AREA ENVIRONMENTAL SAMPLING (WAES)

THE ADDITIONAL MODEL PROTOCOL DEFINES WIDE-AREA ENVIRONmental Sampling (WAES): "*Wide-area environmental sampling* means the collection of environmental samples (e.g., air, water, vegetation, soil, and smears) at a set of locations specified by the Agency for the purpose of assisting the Agency to draw conclusions about the absence of undeclared *nuclear material* or nuclear activities over a wide area."[1]

One proposed model to implement WAES is based on a grid of air samplers. Large grid constants, of the order of a hundred kilometers, or perhaps even larger, were mentioned as a financially viable proposition. The following examines the possibility and efficacy of setting up such a system, first for ideal conditions and then for more realistic ones.

Criteria for Detection

Generally speaking, the proper criterion for detecting atmospheric emissions of physical indicators of illicit activities is the following: Given a threshold concentration value (TV), above which the analysis of a sample would present clear-cut evidence of illicit activities or of the presence of illicit nuclear materials, a necessary and sufficient condition for the detection of these is that the sampler be geographically located within the relevant isopleth of this threshold value.

Care must be taken to utilize all necessary data for the assessment of this threshold value, including: the sampling rate, the analytical threshold values, and the permissible error, taking also into account background values.

Assumptions for Ideal Condition Calculations

"Ideal conditions" are defined as the following:

1. The samplers are distributed in a square grid with a grid constant "a."
2. There is a single source enclosed within the grid, the location of which is unknown.
3. Each and every location within the sampling grid has an equal probability of being the actual source location.
4. The wind direction distribution ("wind rose") is isotropic, i.e., the probability of the wind direction and speed is equal in all directions.
5. The frequency distribution of the stability categories is isotropic.
6. Straight-line transport and Gaussian distributions are assumed.

7. No cloud depletion or any other physical or chemical modifications to the cloud's contents are assumed.
8. The sampling is performed at 100 percent efficiency, i.e., that all particles arriving at the samplers are being collected.

Methodology—General Description[2]

Divide each square delineated by the four sampling grid points at each corner into four sub-squares (of side length a/2). Each sub-square will be similar to the others. Therefore, the calculation will be performed only for points (sources) enclosed within this sub-square. For each of these points the probability of detection will be evaluated.

The evaluation will be done for six distinct meteorological conditions: Stability class A, with a wind speed of 2 meters per second (denoted by "A/2"), and similarly denoting the other five: B/3, C/4, D/5, E/3, and F/2. The stability category G represents stagnant conditions and thus will not be evaluated numerically.

For each point and stability condition the distance to the nearest sampler will be compared with the projected range of detection. If the distance to the sampler is less than the range of detection, there is a probability of detection by the sampler. This probability will be evaluated by calculating the angular opening of the threshold detection level isopleth at the distance to the sampler. The ratio of this opening to the angle of the quadrant, or 90^0, is the probability of detection, because wind direction is assumed to be isotropic.

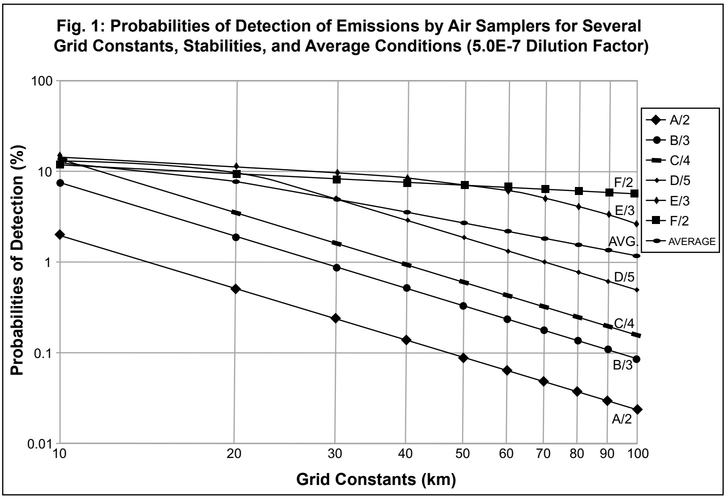
The next stage of calculation is to compare the range of detection with the distance from the source to the other three samplers located at the other three corners of the original square. Should the distance to any sampler be less than this range, the angular opening ratio will be added to the original probability.

No evaluation is done for more distant samplers, mainly because the calculation for large distances is grossly inaccurate, even if only because of the time-varying meteorological conditions and trajectories influencing the results of calculations.

Sample Calculations

Utilizing the above methodology, some sample calculations were performed that qualitatively demonstrate the major results.

Figure 1 (facing page) presents the results of calculations of the probability of sampling significant amounts of effluents, so that their analysis will not produce false-negative results. These calculations were carried out for the six stability conditions mentioned. The effect of reducing the proposed grid constant from the original length of 100 kilometers also is shown.



The main results are:

- The probabilities are not very large, even for small (and thus impractical) grid sizes. The highest calculated value, for a 10 kilometer grid, is approximately 15 percent (for D/5), which is not very high—it is equivalent to a false-negative probability of approximately 85 percent.
- As would be expected, a large grid constant would be more efficient in detecting effluents released during stable conditions, compared to releases under unstable conditions, since the latter would disperse much more quickly, and thus be lost to the samplers from most locations. However, decreasing the grid constant does not cause thecollection of samples to be much more efficient for the more stable conditions. Although the efficiency of collection during unstable conditions would be greatly increased, it would still not be the sameas for the other conditions, even at the much smaller grid size.
- Decreasing the grid constant by a factor of 2—from 100 to 50 kilometers—will increase the probability of sampling by a factor of almost 4 for the unstable categories, while increasing the probability by a factor less than 2 for the most stable condition: F/2.

Figure 2 (page 94) presents the probabilities of sampling for various threshold dilution factors and grid constants, for steady D/5 stability conditions. It can be seen that for the higher sensitivity values there is little purpose in decreasing the grid size.

Figure 3 (page 94) presents data concerning the possible effect of decreasing the threshold value, thus increasing the sensitivity of the system. As could be expected, the major benefit of increasing the system sensitivity

Fig. 2: Probabilities of Sampling for Various Dilution Factors and Grid Constants, for D/5 Stability Conditions

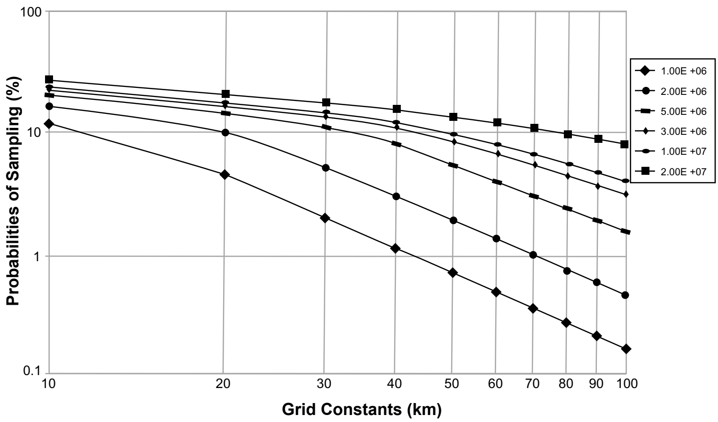
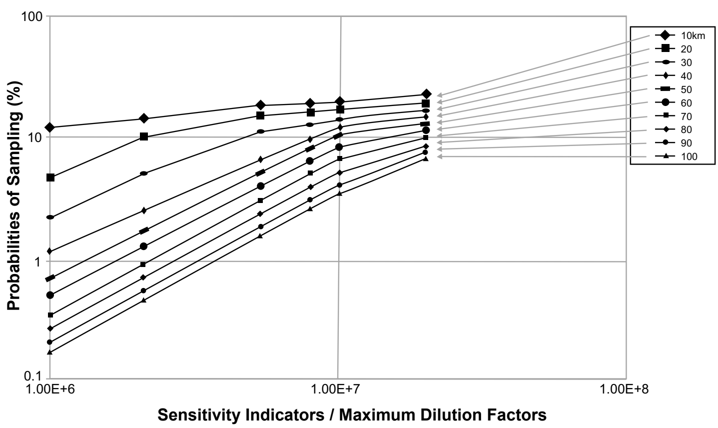


Fig. 3: Effect of Increasing the Analytical Sensitivities on the Probabilities of Detection, for Various Grid Constants (D/5 Stability Conditions)



would accrue when the grid size is large. However, there is some cause to believe that there is a limit to the practical increase in efficiency, since the variation seems to slowly approach an asymptotic to some value much less than 100 percent.

What does this mean in practical terms? It would be relatively easy to detect and locate a relatively large fissile material production operation. This is not, however, the case for a small-scale, low-emission operation. Let us assume a small (R&D) operation that has a throughput of one tonne of uranium per year. Let us assume that $1*10^{-6}$ (one-millionth) of this (1 gram) is discharged into the atmosphere in a single, almost instantaneous, occurrence. Let us assume that an array of heavy-duty air samplers are placed 100 kilometers apart, and that these have a sampling rate of 600 m^3/hr. Let us assume that the threshold of detection, designed to detect a significant increase in the air concentration of uranium, is $1*10^{-8}$ grams (10 nanograms).

For the D/5 case, the limiting distance of detection would be approximately 63 kilometers from the source. However, the probability of detection at this distance would be practically zero, because the angular opening of the isopleth at the extreme range is zero. Therefore, the distance of detection must be shorter, in order to have a higher probability of detection. The probability of detection in this case would be 7.1 percent for a sampling grid size of 100 kilometers, 12.1 percent for a grid size of 50 kilometers, and 21.7 percent for the very small, 10-kilometer, grid constant.

The Effect of Deviating from the Original Assumptions

As stated, the original assumptions were the most conservative ones. In the following, the effect of easing of these requirements will be discussed.

A. Bifurcation conditions: Assume a wind blowing in one direction for half the release time (or half the concentration), and changing to a distinctly different wind direction for the other half, holding all other considerations constant. In the case described above, and taking half the release value, the maximum distance of detection is approximately 38 kilometers (as compared with 63 kilometers). The calculated probability of detection is 3.0 percent for a grid size of 100 kilometers (compared with 7.1 percent for the full release), 9.2 for 50 kilometers (compared with 12.1 percent) and 19.8 for 10 kilometers (as compared with 21.7 percent). Should there be an overlap in areas, the combined probability would be smaller than the sum of each. It can be seen that for the large grid size there is a decrease in the combined (added) probability of detection, while for the smaller sampling grid sizes there would be a benefit, should the wind direction change distinctly during the release.

B. Trying to estimate the meaning of the results of the calculations on the probability of detection by a static grid of air samplers with a grid constant “a,” one has to consider the effects of the following on the outcome of the study:

   a. The threshold of detection is a major factor in investigating the possibility of sampling for the detection of illicit activities. In addition, the threshold of detection is very much affected by the background activity at the sampling site, including legitimate activities with the same environmental signatures, and by the method of analysis (e.g., radioactivity, bulk analysis, single particle analysis).

b. The actual travel trajectory of the plume rather than the (theoretical) straight-line dispersion. This would reduce the straight-line distance of detection (X_{max}).

c. The persistence of the stability conditions. While unstable conditions could very well persist for the short travel distances, it would be an extreme case that a specific (long) release would travel for its whole release time and for more than 10 hours' travel time in a straight line with unchanging dispersion characteristics under nighttime conditions (E,F,G).

d. The maximum distance of detection is dependent on the source-term. It must be noted, though, that "n" would be less than 1 in an X^n approximation of the variation of the distance of detection with the source-strength (See Figure 1).[3] If the release is not accidental, but results from planned activities, the source facility could take evasive actions such as planning the release during unstable conditions and introducing release-prevention measures.

e. In an actual situation, there would be no chance of obtaining a sample that would give positive results at the absolute extreme range of detection, because of the meandering of the cloud, and the fact that the dispersion equations do not take this effect into account and have to be corrected, thereby reducing the effective range of detection.

f. The topographical features at the source, en route, and at the sampler also have a significant effect on the probability of detection. If the release occurs at a site deep inside an urban area, cloud depletion by deposition could play a major part in the fate of sampling. Major topographic features will have an effect both on the trajectory and on cloud depletion. Mountains and valleys will divert the trajectory. Forests will increase cloud depletion.

The most important effect that influences the outcome of both the calculations and their practical outcome is the deposition of the airborne particles on the ground and on surfaces. Deposition takes place by either dry or wet deposition. The effect could be very serious. Deposition rates are dependent on particle sizes and their distribution.

Since the more common mechanism is dry deposition, especially in many areas of concern where precipitation is uncertain, we shall deal with this issue only in the context of dry deposition. The two major effects of deposition are: shortening the range of detection, thereby reducing the detection probability; and increasing the surface concentration of those materials that are the target of detection.

For the estimation of the effect of deposition on both the range of detection and on its probability the source depletion calculation equation, as described in Slade was used:[4]

$$\ln\left(\frac{Qx}{Qo}\right) = \left(\frac{2}{\pi}\right)^{0.5}\left(\frac{Vd}{U}\right)\int_0^x \frac{dx}{\sigma z}$$

Where:

- Vd is the deposition velocity (m/sec). This is a virtual velocity, describing the ratio between surface and air concentrations at any distance x from the source. Therefore, Vd is surface dependent.
- Q_0 is the source term.
- Q_x is the corrected source term for distance x, after the effect of deposition at distances nearer the source was taken into account.

Figure 4 presents the effect of deposition on the probability of detection for the "benchmark case," during which an instantaneous emission of 1 gram occurs, and the detection threshold value is 10^{-8} grams. A deposition velocity value Vd=0.01 is assumed. The results are presented for several grid sizes and stability conditions.

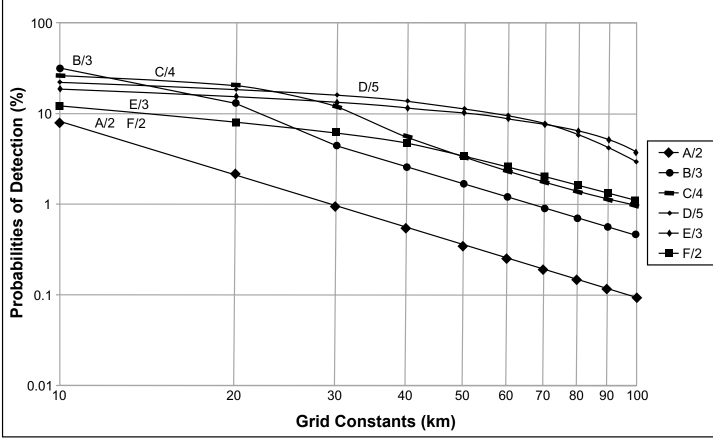
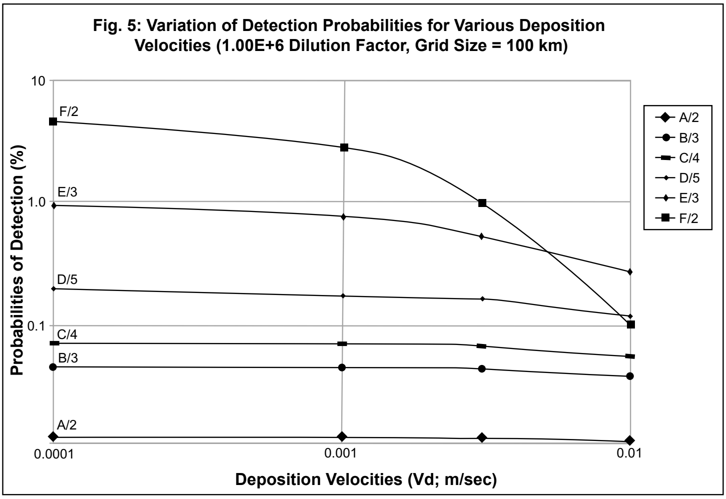


Fig. 4: Probability of Detection for the Benchmark Case, for Various Stability Conditions

Figure 5 (page 98) presents the effect of ground deposition on the detection probability for several deposition velocities and stability conditions, for a 10^6 dilution factor and a=100 kilometers. (The 0.0001 m/sec value for the deposition velocity represents the asymptotic value for Vd=0).

The following observations can be made:

- While the deposition of particles does not affect the low probability of detection during unstable conditions (A through C), it does affect the higher detection probabilities of the more stable categories.
- As expected, the higher the deposition velocity, the lower the probability of detection becomes, since the air concentrations of particulate matter decreases more rapidly with increasing deposition.



- Although the probability of detection is relatively high for a dense air-sampling grid, the detection probabilities achieve very low (well below 10 percent) values for the grid size of 100 kilometers. In addition to the above one must note that although the deposition velocity is not a physical quantity, there is a relation between the deposition rate and the ability of the samplers to collect the particles. Large particles, which would be more efficiently collected by the samplers, would have a higher deposition rate. On the contrary, a very low deposition velocity would probably mean a low efficiency in air sample collection.

Detection of Illicit Activities by the Sampling of Deposited Materials

Although the above discussion could lead to a natural conclusion that a dense enough deposition sampling grid could assure the detection of illicit activities, this is not the case. Table 1 (facing page) presents the maximum distances of detection of deposited particles, for several deposition velocities and stability conditions, taking the benchmark case (Figure 4) as the basis for the calculations. The distances are quite short, and without even calculating the probabilities, it is evident that any deposition-sampling grid will have to be on the order of one kilometer, at most.

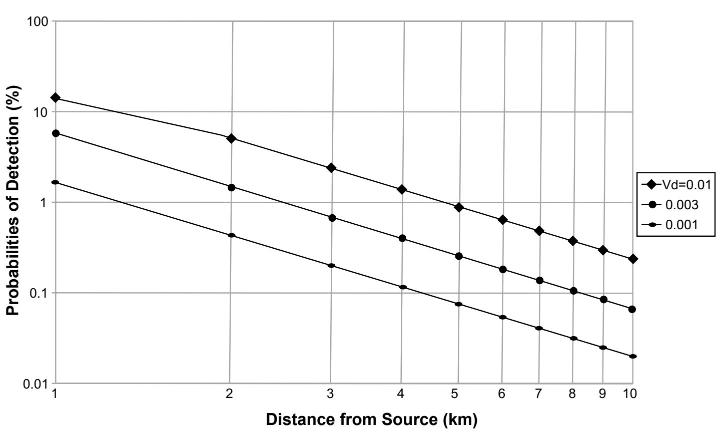
These probabilities are very low. However, this would be manageable, and even necessary in special circumstances, such as in urban, densely builtareas, where no other sampling method would give any reasonable chance of detection. In addition, the sampling points do not have to be rigidly fixed. If a moving frame of reference is adopted, a smaller size grid is adopted, in effect, raising the probability of detection by this method.

Table 1: Variation of the (approximate) Maximum Distance of Detection (meters) of Deposited Materials for the Benchmark Case under Various Stability Conditions

	Stability Conditions					
Vd (m/s)	A/2	B/3	C/4	D/5	E/3	F/2
0.01	500	720	1,020	1,600	2,600	2,660
0.003	340	420	560	900	1,720	3,060
0.001	210	240	320	480	940	1,950

Figure 6 presents the probability of detection for three deposition velocities, based on the benchmark case, and D/5 stability conditions. One should note that only for the 1 kilometer distance and the high Vd is there a higher than 10 percent probability of detection of the deposited particles from a single release.

Fig. 6: Probabilities of Detection of Deposited Particles for Three Deposition Velocities (Benchmark Case, Stability Condition D/5)



Discussion: The Prospects for a Wide-Area Sampling Program

It should be realized that no environmental monitoring system could assure absolutely the absence of illicit nuclear materials and activities. Only a very dense sampling grid could give some assurance that there is a good chance that the state in question was not conducting any illicit activities. If no other reliable information is available, the environmental survey must proceed under the assumptions that either the source-term is very small, or that the sampling and analysis methods are not sensitive enough.

The major drawbacks of an air sampling system utilizing a small grids constant are:

- Low sampling probability, i.e., a large false-negative result probability. If the "single" incident, which caused the release of the source material, took place at a time and in such conditions that the plume bypassed all samplers and was lost, no record of the incident would remain, and all possibility of identifying a source would be gone.
- High cost of installation and maintenance.
- Non-reproducibility of the results.
- A positive finding could be a single-point result, not facilitating the backtracking of the plume, because of the duration of each sampling period (week or month), preventing any indication of location, because of the long-term variation of the meteorological conditions.

A static air sampling system can provide reasonable-to-high probability assurances of detecting an illicit gas-centrifuge uranium enrichment facility only in cases where either a very small grid constant or a very large source-term is assumed. There should be a higher probability of detecting a reprocessing facility, a gaseous-diffusion plant, or electromagnetic isotopic separation (EMIS) uranium enrichment sites. These probably would have larger source-terms, and some typical emissions of reprocessing plants, consisting of noble gases or volatiles, are harder to contain.

In addition to being unwieldy, an air sampling array, with a grid constant of some 50–100 kilometers, has a high probability of producing false-negative results. In the case of the proliferation of nuclear weapons, a false-negative report is impermissible.

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[1] "Model Protocol Additional to the Agreement(s) Between State(s) and the International Atomic Energy Agency for the Application of Safeguards," INFCIRC/540, (Vienna: International Atomic Energy Agency, 1997).

[2] The actual method of calculation follows:

1. Determine the threshold-of-detection value (TV). Assume a single, short event that releases the effluents into the atmosphere. Although no exact prescription for this evaluation will be given, the total integrated concentrations have to be calculated, the amount sampled, and the analytical thresholds (include the possible effect of background levels) must be taken into account.
2. Assume Gaussian, straight-line dispersion, steady conditions, no depletion or modification conditions, as the most conservative situation for maximum range of detection.
3. For each stability category (and its assumed representative wind speed) find the extreme detection distance, X_{max} where C=Threshold Value (TV). An iterative process is the easiest way to accomplish this.
4. For each possible location of the source, calculate the distance X to the nearest sampler.
5. Calculate f, $f=C(X_{max})/C(X)$.
6. Find (or calculate) $\sigma_y(X)$.

7 Calculate Y(X) by $Y=[2\sigma_y^2 \ln(1/f)]^{1/2}$ (this is the maximum width of the threshold isopleth).

8 Calculate the angle a defined as the $2*\tan^{-1}(Y/X)$. Dividing this angle by 900 (or $\pi/2$, as the case may be) gives the probability of detecting the activity at the source of distance X.

9 Repeat the calculation for the other samplers of the square grid, if for any i, i=1, 3 the range to the sampler at point i is less than the detection range.

10 Repeat the calculation for all stability conditions, then assume the known stability distribution for the area under consideration or assume a generic distribution (e.g. A – 5%; B – 7%; C – 13%; D – 50%; E – 13%; F – 10%; G (calm) – 2%). Sum the probabilities and normalize them.

[3] This figure is presented for showing the TREND of the variation, not for any estimate of absolute values, since the threshold detection values are not the same for all cases.

[4] Slade, David H., *Meteorology and Atomic Energy*, (Washington, DC: U.S. Atomic Energy Commission, 1968), equation 5.47.

APPENDIX 2

THE UN STANCE ON VERIFICATION: THEORY AND PRACTICE

AT THE 1987 AND 1988 SESSIONS OF THE UNITED NATIONS Disarmament Commission (UNDC), a Working Group prepared "Sixteen Principles for Verification." The UN General Assembly, in Resolution A/RES/43/81 (B), which was adopted on December 7, 1988, endorsed these Principles. In addition, the General Assembly's resolution stated that arms control and disarmament agreements "should provide for adequate and effective measures of verification…in order to create the necessary confidence and to ensure that they are being observed by all parties." The resolution also noted that the verification mechanism—its "forms and modalities"—is dependant on the "purposes, scope, and nature of the agreement."

In 1988, the General Assembly asked the Secretary General to form an Expert Group that would prepare a report on the role of the United Nations in the verification field. Following the submission of this report the Secretary General was requested to submit a follow-up study. This study,[1] which was unanimously approved by a group of governmental experts on "Verification in all its Aspects," was submitted in 1995, where it obtained the approval of the UN First Committee and was commended by the General Assembly to the attention of its members.

The Sixteen Principles

1) "Adequate and effective verification is an essential element of all arms limitation and disarmament agreements."

This principle defines the role of verification as the assurance that no contravention of the verified agreement has taken place. It also states that verification must be adequate and effective—conditions which are addressed in subsequent principles. However, this principle ignores the possible deterrent role of verification.

2) "Verification is not an aim in itself, but an essential element in the process of achieving arms limitation and disarmament agreements."

This is a good principle that both the inspectors and the inspected state should remember. Having a verification mechanism in place can never be taken as an accomplishment by itself. Only when verification is "adequate and effective," as called for under the first principle, can a degree of satisfaction be permitted.

3) "Verification should promote the implementation of arms limitation and disarmament measures, build confidence among states, and ensure that agreements are being observed by all parties."

This principle is somewhat self-contradictory, since without being confidence-based, verification has little chance of success.

4) "Adequate and effective verification requires employment of different techniques, such as national technical means, international technical means, and international procedures, including on-site inspections."

The world has come to recognize that national technical means (NTM) has a role to play in the verification of arms control agreements. However, the exact definition of NTM is at times elusive and/or unacceptable to states. The legitimate wish of sovereign states to protect themselves against unwanted and unwarranted intrusion into their national affairs prevents the universal application of this part of this principle.

"International technical means" are not universally acceptable and usually must be defined for each agreement. By unequivocally including on-site inspections, the principle ignores the need to protect the legitimate interests of the inspected state, and the possibility of offering alternatives to on-site inspections that would satisfy the verification needs whilst protecting those national interests.

5) "Verification in the arms limitation and disarmament process will benefit from greater openness."

Openness is a requirement for successful verification. Lack of openness on matters pertaining to verification is tantamount to concealment, which (if discovered) would threaten confidence that the agreement is being honored by the inspected state.

6) "Arms limitation and disarmament agreements should include explicit provisions whereby each party undertakes not to interfere with the agreed methods, procedures, and techniques of verification, when these are operating in a manner consistent with the provisions of the agreement and generally recognized principles of international law."

This principle assumes that the fifth principle—the need for openness—will not be obeyed. Only thus can we explain the mention of non-interference when openness was already agreed on. It also acts as an essential addendum to the fourth principle (NTM) by mentioning the need for the verification techniques to conform to generally recognized principles of international law. In the Comprehensive Nuclear Test-Ban Treaty (CTBT), this principle is taken into account.

On the other hand, this principle requests, albeit indirectly, that the methods, procedures, and techniques of verification be agreed upon. This will protect the state against unwanted intrusion and the acquisition of irrelevant information that could be harmful to inspected state's interests. Constraints upon verification procedures could cause some limitations to the inspectorate.

7) "Arms limitation and disarmament agreements should include explicit provisions whereby each party undertakes not to use deliberate concealment measures which impede verification of compliance with the agreement."

This principle needs no further elaboration, as it reinforces the sentiments expressed in the fifth principle.

8) "To assess the continuing adequacy and effectiveness of the verification system, an arms limitation and disarmament agreement should provide for procedures and mechanisms for review and evaluation. Where possible, timeframes for such reviews should be agreed in order to facilitate this assessment."

This is a salient point that is not universally applied. For example, while it is applied in the International Atomic Energy Agency's (IAEA's) routine safeguards work, it is not sufficiently applied in the work of the IAEA Action Team. Frequent review and oversight activities are extremely important for maintaining the professional quality of work and assuring the integrity of operations.

9) "Verification arrangements should be addressed at the onset and at every stage of negotiations on specific arms limitation and disarmament agreements."

Fully implementing this principle would bring much rationalization to the demands from verification. There are some requirements (especially related to negative verification) that cannot be met.

10) "All states have equal rights to participate in the process of international verification of agreements to which they are parties."

This principle is obviously flouted, since states are permitted to veto the appointment of inspectors, even when some agreements state that these cannot be objected to on the grounds of nationality. (In the diplomatic world, cases have been known to occur where the reasons given for vetoing inspectors' appointments were inaccurate.)

An outstanding example of disregard for this principle occurred when the UN prevented Israel from participating in the process of verifying the elimination of Iraq's nuclear, chemical, biological, and long-range missile programs, even though Israel was one of the main sufferers from Iraqi aggression during the Gulf War. Having adversaries participating in the verification activities assures the world of a less lenient approach and increases the probability of fulfilling the verification mission.

11) "Adequate and effective verification arrangements must be capable of providing, in a timely fashion, clear and convincing evidence of compliance or noncompliance. Continued confirmation of compliance is an essential ingredient to building and maintaining confidence among the parties."

This is a beautiful principle, albeit one that is most difficult to uphold. It is very difficult to present "clear and convincing evidence" of compliance using positive verification methodologies. Negative verification cannot normally be proved clearly and convincingly: one cannot verify noncompliance—the absence of nuclear material, especially if it was not indigenously produced, or the absence of any low-key R&D activity related to the production of nuclear weapons.

12) "Determinations about the adequacy, effectiveness, and acceptability of specific methods and arrangements intended to verify compliance with the provisions of an arms limitation and disarmament agreement can only be made within the context of that agreement."

This principle overlooks the value of setting up of impartial international expert groups on an as-needed basis to help judge the "adequacy, effectiveness and acceptability" of a treaty's verification mechanism.

13) "Verification of compliance with the obligations imposed by an arms limitation and disarmament agreement is an activity conducted by the parties to an arms limitation and disarmament agreement or by an organization at the request and with the explicit consent of the parties, and is an expression of the sovereign right of states to enter into such arrangements."

Some states tend to forget or ignore "the sovereign right of states to enter into such arrangements."

14) "Requests for inspections or information in accordance with the provisions of an arms limitation and disarmament agreement should be considered as a normal component of the verification process. Such requests should be used only for the purposes of the determination of compliance, care being taken to avoid abuses."

This principle recognizes the possible conflict between the need for openness (fifth principle) with the legitimate right of states to protect their national interests, so long as those interests do not constitute a violation of the treaty being verified. These two interests must be balanced. This principle does not address the issue of compensating a state for being falsely accused or abused.

15) "Verification arrangements should be implemented without discrimination, and, in accomplishing their purpose, avoid unduly interfering with the internal affairs of states parties or other states, or jeopardizing their economic, technological, and social development."

This is a continuation of the previous principle. However, the sweeping statement concerning the application of verification in a nondiscriminatory manner is not always logical.

16) "To be adequate and effective, a verification regime for an agreement must cover all relevant weapons, facilities, locations, installations, and activities."

This principle indicates the importance of assuring both the correctness *and completeness* of a state's declaration to the IAEA. In that sense, it is a forerunner of the Model Protocol (INFCIRC/540). Were this principle implemented in 1988, when the "Sixteen Principles" were adopted, it is possible that Iraq may have been deterred from further seeking nuclear weapons, or its program could have been more readily discovered.

The Secretary General's Report

The Secretary General's Report defines "verification" as "a process in which data is collected and analyzed in order to make an informed judgment as to whether a party is complying with its obligations." In addition, the report states that verification's primary goal is to "increase the level of transparency in relation to relevant activities to a point where a determination regarding compliance can be reliably made." Moreover, "confidence-building measures seek to reduce misperception and misunderstandings, as a first step towards replacing suspicion with confidence, by enabling parties to be more transparent about their intentions in specific circumstances."

While the definition is reasonable, the statement describing the increase in the level of transparency as the primary *aim* of verification is not acceptable. Rather, transparency is a *requirement* of adequate and effective verification. Without transparency on the side of the inspected state, verification could very well fail, as the IAEA Action Team's experience in Iraq has shown.

Lessons Learned

The Secretary General's report contains a number of "Lessons from Recent Experience," not all of which lead to sound recommendations for improving verification.

On the positive side, the report notes that transparency is central to both effective and cost-effective verification. Confidence-building measures are also endorsed. In reality, transparency and confidence-building measures are synonymous: Any confidence-building measure that does not include a degree of transparency on the part of the inspected state will contribute little to the overall evaluation of the verification data. At the same time, transparency is such a magnificent source of confidence that nothing much else would be needed to bring about the desired result.

Under the heading of "Undeclared Activities and Facilities" the report correctly warns against making absolute guarantees based upon the findings of negative verification. The report notes that "verifying the absence of undeclared activities and facilities implies a requirement to ensure agreed access to information and sites." However, the report further warns that "enhanced openness, while it will help, may not give an absolute guarantee of the absence of undeclared activities and facilities."

Events subsequent to the issuance of the Secretary General's report bear out this statement. The international community did not heed this warning when judging the situation in member states, regarding nuclear verification activities in general, and the situation in Iraq in particular. As the case of Iraq shows, the verification mechanism cannot perform its task without having complete access on its side, and without the inspected state offering complete transparency. Because sovereign states seldom offer complete, or almost complete, transparency (South Africa being a notable exception), compliance can be rarely assured.

In a subsequent section, the report states: "In many circumstances it is virtually impossible, for technical reasons, to guarantee the absence of undeclared activities or objects. Care must therefore be taken to distinguish between the high level of assurance which can generally be provided in respect of the verification of declared activities and the necessarily lower level of assurance which verification can provide in relation to undeclared activities."

These are very wise words; if only the UN would practice what it preaches. Verification is a technical activity. The results of this technical activity will determine the adequacy and effectiveness of this activity and the degree of assurance obtained. These results cannot be made by a preconceived political determination.

On the negative side, the report repeats the illogical mantra that "future multilateral arms limitation and disarmament agreement must be nondiscriminatory in their restrictions and their verification regimes." This is a great sentiment, albeit one that should not be indiscriminately applied.

This is especially true regarding the verification mechanism, which should be subject oriented, and focused on those states where is it most greatly needed (see chapter 11).

The report also suggests that neutral, “third party” verification be sought, especially where hostility exists among the parties. However, neutral parties are liable to protect their image and not take sides in a dispute, thereby lowering the level of confidence and reliability in its verification activities.

As a finale to this appendix, it should be noted that Iraq (and some other UN members) objected to some of the ideas contained in the Expert Group report.

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[1] “Verification in all its Aspects, Including the Role of the United Nations in the Field of Verification,” Report of the Secretary General, A/50/377, September 22, 1995.