DETECTION OF UNDECLARED NUCLEAR ACTIVITIES: DOES THE IAEA HAVE THE NECESSARY CAPABILITIES?

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Abstract

Establishing an effective capability to detect undeclared nuclear activities is the greatest challenge facing IAEA safeguards. This has been a major focus of safeguards development over the last 15 years. This paper outlines what has been achieved and what more needs to be done.

The paper looks at the following issues: What is the safeguards mission – what are safeguards trying to detect? And what conclusions can safeguards reach? Does the IAEA have the necessary tools – institutional and technical – to fulfil this mission? What more is required?

With some exceptions, traditional safeguards have demonstrated a substantial capability to counter acquisition paths involving declared facilities - removal of nuclear material from declared facilities, and/or misuse of such facilities. Acquisition paths involving use of undeclared nuclear material and undeclared facilities are more problematic. Addressing these involves legal measures – improving the IAEA's authority, especially through the Additional Protocol – and technical measures – improving detection techniques. While much has been achieved, this is an ongoing long-term program, and much more needs to be done.

Now some are questioning whether the Additional Protocol is adequate, or whether the IAEA needs still greater authority. The Iranian situation illustrates the practical challenges in detecting undeclared activities, and possible deficiencies in the IAEA's authority. The Iranian case also shows the need for clarity in the IAEA's mission. What kind of activities is it reasonable to expect the IAEA to detect? And can the IAEA be expected to establish that a nuclear program is for exclusively peaceful purposes? These questions are central to both the future development and the credibility of the safeguards system.

1. INTRODUCTION

The IAEA's safeguards capabilities can be considered in two broad categories – technical and legal. The various technical measures employed by the Agency can also be considered in two categories – **monitoring**, scanning for possible indicators of undeclared activities where there is no prior information suggesting they might exist; and **investigation**, where indicators are found and need to be followed up. Monitoring activities are not necessarily location-specific, and do not necessarily require access in the state - an example is information collection and analysis. Some techniques can be used for either monitoring or investigation – these include satellite imagery (which obviously does not involve access to the state) and environmental sampling/analysis, which can be location-specific or could involve wide-area monitoring.

Legal capabilities relate to the IAEA's authority to employ particular measures. Generally issues of authority will concern the Agency's right of access to specific locations. They can also relate to the Agency's right to request particular information, and its right to question specific persons. By their nature, issues of authority are most likely to arise in cases where the Agency is investigating safeguards breaches.

As will be discussed, the safeguards mission today is very different to that of 35 years ago, when the model comprehensive safeguards agreement, INFCIRC/153, was developed. Detecting undeclared nuclear material/activities involves very different issues compared with verification of declared material/facilities. There is a far greater degree of uncertainty in the safeguards conclusions that can be reached, i.e. as regards the absence of undeclared material/activities activities – this affects not only the nature of the safeguards conclusions, but also decisions on the appropriate degree of effort to be devoted to countering the possibility of undeclared material/activities.

Verification of declared material is finite – the measures and effort necessary to reach safeguards conclusions are well-established. On the other hand, verification of the absence of undeclared material/activities can be open-ended. Clearly a line has to be drawn somewhere - but the international community needs to be confident that a finding of no indication of undeclared material/activities does not simply reflect inadequate effort.

2. THE EVOLVING SAFEGUARDS MISSION

The nature of the safeguards mission – what the safeguards system is seeking to achieve - can be considered at a number of levels: what is required under the NPT, what is required under safeguards agreements, and the expectations of the international community.

INFCIRC/153 is framed in terms of safeguards procedures to be applied to **nuclear material**. The agreement provides that the IAEA has the right and obligation to ensure safeguards are applied to all nuclear material in the state, to verify that such material is not diverted to nuclear weapons or nuclear explosive devices[1]. This basic statement is elaborated further in the safeguards agreement's description of the "objective of safeguards":

> "… the timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or of other nuclear explosive devices or **for purposes unknown** …." (bolding added)[2]

Safeguards procedures are not limited to nuclear material - see the authors' parallel paper on "Nuclear Weaponisation Activities: What is the Role of IAEA Safeguards?" This point is central to the development of the Additional Protocol, discussed later.

The interpretation of the provisions of INFCIRC/153 agreements, in terms of safeguards implementation and the expectations of the international community, has evolved over time, and is continuing to evolve. Until the 1990s the principal task of safeguards was generally seen as to confirm the **correctness** of state declarations. It was thought that any undeclared nuclear material/activities would be revealed through diversion of declared nuclear material or misuse of declared facilities. Hence the safeguards agreement's focus on nuclear material, nuclear accountancy, and regular inspections.

Since the early 1990s, the emphasis has turned to detection of undeclared nuclear material/activities, what is referred to as confirming the **completeness** of state declarations. It is now recognised it is quite likely there will be no obvious links between the declared nuclear program and undeclared nuclear material/activities.

The detection of wholly undeclared nuclear material/activities is much more of a challenge than confirmation of the correctness of declarations. It has been necessary to develop a new range of

1. INFCIRC/153 paragraph 2.
2. INFCIRC/153 paragraph 28.

verification methods and technologies, including information collection and analysis, environmental analysis, use of satellite imagery, and so on. Although these techniques can be viewed as being "technical" in nature, decisions on which measures should be applied and the intensity of their application – how much is "enough" to fulfil the safeguards mission - involve qualitative judgment. Technical implementation – a judgment on what is required to be done - needs to be guided by a clear understanding of the safeguards mission. This in turn can be guided by an understanding of the kind of findings and conclusions the Agency is able to reach.

3. DRAWING CONCLUSIONS ON UNDECLARED NUCLEAR MATERIAL/ACTIVITIES

The IAEA reports in the annual Safeguards Implementation Report (SIR) whether it found any indication of diversion or any indication of undeclared nuclear material/activities. These "findings" are then used to support **conclusions**.

Traditionally the IAEA expressed its conclusions in terms of **declared** material:

> "All the information available to the Agency supports the conclusion that the nuclear material and other items placed under safeguards remained in peaceful nuclear activities or were otherwise adequately accounted for." [3]

Once the IAEA began to implement safeguards measures under the Additional Protocol, however, there was an expectation that it would also draw a conclusion on its findings about the absence of **undeclared** nuclear material/activities. The Agency did this for the first time in the SIR for 2000, when it reported:

> "In 2000, in respect of seven States, the Secretariat - having evaluated all the information obtained through activities pursuant to these States' comprehensive safeguards agreements and additional protocols as well as all other information available to the Agency - found no indication either of diversion of nuclear material placed under safeguards or of the presence of undeclared nuclear material or activities in those States. On this basis, the Secretariat concluded that **all nuclear material in those States had been placed under safeguards and remained in peaceful nuclear activities or was otherwise adequately accounted for**." (bolding added)

It is essential that the IAEA's conclusions on the absence of undeclared nuclear material/activities are **credible**. As already noted, the international community must be confident that the absence of indicators does not simply reflect inadequate verification effort. The IAEA is devoting considerable effort to the development of verification methods that will provide a credible result. In this regard, credibility will depend on a number of factors: that the verification methods are appropriate; that they are implemented appropriately in each case (which involves issues of quality assurance); and that the Agency's practices are adequately understood by the international community.

It is essential for states to understand what the IAEA means by a conclusion on the absence of undeclared nuclear material/activities. Such a conclusion is not unqualified - it is important not to confuse credible assurance with certainty. It is never possible to prove a negative with absolute certainty. For at least the last thirty years, the IAEA has recognised that it is necessary to draw its conclusions on the balance of probabilities. There has been a substantial effort to ensure the credibility of the conclusions drawn, but it was recognised that seeking higher levels of assurance rapidly falls victim to the law of diminishing returns.

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3. SIR for 1998.

In the case of the physical verification of nuclear material, this problem of decreasing returns from additional effort has been very well quantified. In the case of the annual Physical Inventory Verification (PIV) carried out at facilities with significant quantities of nuclear material, the inspection plan is made with the explicit aim of achieving a 95% probability of detecting the diversion of 0.3 SQ of nuclear material. It has been demonstrated that aiming for a higher degree of certainty results in substantial increases in the resources that need to be expended on each inspection (e.g. there are circumstances where aiming for 99% detection probability would result in orders of magnitude increases in the cost of inspection).

Some of the new verification measures available to the IAEA could be used in a quantitative mode, but only at prohibitive cost. For example, it would be possible to order and analyse imagery covering 100% of a state's territory – but except for the very smallest of states, this would cost a significant proportion of the total safeguards budget without really providing much more in the way of detection capability than the current focussed approach to imagery analysis.

Many of the new detection measures being used by the IAEA provide qualitative information that could never be made equivalent to the quantitative certainty provided by materials accountancy and control measures. In spite of the difficulty in assigning a numeric level of certainty arising from a particular verification method, the measures are effective and have a real deterrent effect on potential proliferators.

One aspect of conclusions about undeclared nuclear material/activities concerns the significance of the detection of such material/activities, and whether their existence constitutes **diversion**. Is it sufficient for the IAEA to show a failure to declare, or is something more required, such as evidence of nuclear weapon intent?

It is most unlikely the IAEA will catch a state red-handed, e.g. by finding a nuclear weapon or nuclear material in the form of nuclear weapon components. It is more likely a state facing exposure in this way would deny access, preferring to argue whether lack of cooperation constitutes non-compliance, and to be able to maintain some ambiguity about its actions. For this reason, the reference in INFCIRC/153 paragraph 28 to diversion to "**purposes unknown**" is very important. The framers of INFCIRC/153 realised that the standard of proof should not be set unrealistically high: it is sufficient if the IAEA finds that nuclear material is unaccounted for, or has not been declared, that the purpose behind this breach of safeguards is not known, and that a nuclear weapon purpose is plausible in the circumstances.

This understanding of what it is the IAEA needs to demonstrate should help to guide what the Agency needs to do. To "prove" the existence of a nuclear weapon program is too demanding – all the more so when the Agency itself considers there are limits in how far it can go in this area (see the authors' "weaponisation" paper, referred to earlier), but in any event detection of weaponisation activities will be very difficult. Depending on the circumstances, the existence of undeclared nuclear material/activities raises a presumption of diversion – especially if direct-use material, enrichment or plutonium separation are involved. The more additional information the IAEA can gather the better – this will help to make the judgment whether a weapon purpose is plausible in the circumstances. Detection and investigation of apparent weaponisation activities should be part of the IAEA's remit, but are not essential to support a finding of diversion/non-compliance.

4. ISSUES OF TECHNICAL CAPABILITY

Detection of undeclared nuclear activities, especially centrifuge enrichment activities, is generally recognised as the greatest single challenge facing safeguards. The IAEA has introduced a number of measures to address this problem, including wider reporting requirements (through the Additional Protocol, INFCIRC/540) and information collection and analysis. In the latter area, of particular importance is the Agency's work on analysis patterns of nuclear trade. This has involved the establishment of a specialist nuclear trade analysis unit (NUTRAN) within the IAEA, and efforts to improve liaison and information exchange with national organisations involved in similar analysis efforts.

The members of the NUTRAN were drawn from the IAEA's Iraq Nuclear Verification Office (INVO) – a specialist group within the IAEA that spent 13 years unravelling Iraq's clandestine nuclear procurement networks in the period between the first and second Gulf Wars. The methodology and work practices developed by INVO for the Iraq situation were directly applicable to the problem of tracing and understanding Iran's clandestine procurement efforts and for examining the nature and extent of the A Q Khan nuclear smuggling network.

NUTRAN receives information on trade in the items listed in the Additional Protocol (AP) Annexes for those states with an AP in force, and is dependent on voluntary reporting by supplier states for trade involving states without an AP, and for items and non-nuclear materials not included in the AP Annexes.

Currently the AP Annexes include items that are "especially designed or prepared" for nuclear use, and which are intended for nuclear use. They do not include dual use items. There are proposals to amend the AP Annexes to include dual use items. These additions could be based on the NSG's dual use list, INFCIRC/254/Part 2. However, the NSG list is very broad, and a practical issue is whether the IAEA could face a "data flood" that would require inordinate effort to manage and analyse. The IAEA has suggested the establishment of an expert working group to review the AP Annexes and advise the Board on amendments. An issue to be considered is whether to narrow down or prioritise the extent of the amendments, or to make reporting on some items subject to request.

Another important aspect is to broaden reporting from simply exports, to include export denials and procurement enquiries.

Information analysis is important for identifying issues for further investigation, but without location-specific information there is a limit to what can be achieved. This is where detection techniques are essential. The IAEA is currently pursuing a program to explore the application of novel technologies to safeguards – especially in the detection of undeclared materials and activities.

A series of meetings and working groups have been held as part of this program and 60 potentially viable, new technologies have been proposed to the IAEA. At a technical meeting in March 2006[4] the following points emerged:

- at present, the IAEA has limited capability to detect and locate undeclared enrichment activities at distances in the order of tens to hundreds of meters. However, technical innovations in recent years have provided possible solutions;
- there is a need for additional information to better support IAEA information analysis, including information on trade in relevant goods and services, expanded access to scientific and engineering publications, information sharing by states concerning export license denials, etc.;

4. "Novel Techniques and Instruments for Detection of Undeclared Nuclear Facilities, Materials and Activities", Julian Whichello, IAEA, Member State Support Program General Meeting – 14-17 March 2006, Vienna.

- the effectiveness of the Agency's Satellite Imagery Analysis Unit could be further enhanced through access to information on characteristic imagery signatures of facilities used in various enrichment processes and high-spatial-resolution thermal and hyperspectral data;
- the Agency should evaluate the usefulness of secondary signatures, other than nuclear material isotopics, that are contained in collected environmental samples. In addition, the Agency should evaluate the possible use of on-site trace-level measurement of elemental, or chemical compounds (e.g. by laser ablation techniques, etc.);
- air sampling near locations where undeclared enrichment activities are suspected would provide the Agency with additional useful information about the activity's nature, type and location;
- the Agency needs to develop approaches that will be effective for the detection of a range of undeclared enrichment processes, including AVLIS, MLIS, chemical and ion exchange, plasma, etc.

Regardless of the development of new detection techniques – which will take some time, and the effectiveness of which is at this time unknown – there is no doubt that national intelligence information will continue to have a vital role in the detection of undeclared nuclear activities. Safeguards and intelligence must work in partnership in this task.

5. ISSUES OF AUTHORITY

The Additional Protocol is intended to address shortcomings in the IAEA's authority to access locations beyond the "strategic points" of traditional safeguards. For states that so far have not concluded an AP, the IAEA's rights of access remain constrained, though it has a powerful tool in the form of special inspections, to date little used. Special inspections can allow access anywhere in a state, but there is an expectation they would be used only as a last resort. Under the AP, the Agency has access to a wide range of locations, briefly outlined as follows:

- anywhere on a nuclear site[5];
- nuclear-related locations of a kind specified in the AP[6];
- other locations specified by the Agency, where required to resolve a question or inconsistency[7].

Recently there has been some discussion whether the AP is entirely adequate. Some have suggested that the notice period (which for locations other than nuclear sites is at least 24 hours) and consultation requirements in the AP could unduly delay access where this is required quickly. This does not appear to be a problem if nuclear material is involved - nuclear material will leave an environmental signature that is long-lasting and difficult to remove or conceal[8]. However, items of equipment, non-nuclear materials, documents and the like could be removed within the notice period.

Another issue is that access to locations specified by the Agency to resolve a question or inconsistency is qualified: in the first instance the Agency is to take environmental samples[9]. Where the results do not resolve the question or inconsistency (a matter that could take some time to determine), the Agency may use visual observation, radiation detection and measurement devices, and other objective

5. INFCIRC/540 Article 5.a.(i).
6. INFCIRC/540, Article 5.a.(ii) and (iii), Article 5.b.
7. INFCIRC/540, Article 5.c.
8. As demonstrated by Iran's unsuccessful attempts to eliminate traces of uranium enrichment at the Kalaye Electric location.
9. INFCIRC/540, Articles 5.c, 6.d.

measures agreed with the state. Further, the AP anticipates circumstances when the state may be unable to provide access, in which case the state is to make every reasonable effort to satisfy Agency requirements at adjacent locations or through other means. At this stage there is insufficient experience to be able to say how well these provisions will work in practice.

A related issue concerns the IAEA's authority to interview specific individuals. The IAEA Statute specifies that Agency inspectors are to have access "to any person who by reason of his occupation deals with materials, equipment or facilities which are required by this Statute to be safeguarded"[10]. This would appear to cover a broad range of people, including most people involved in a nuclear program.

There is a good argument that the AP is not sufficient for following up a case of non-compliance. There would be advantage for the IAEA to have stronger authority, as was done in Iraq under UNSC Resolution 687 (which of course pre-dated the AP). Where non-compliance has been reported to the Security Council, more rigorous verification authority could be included in a Security Council resolution. This might include anywhere/any time access, installation of monitoring systems, authority to interview any person, and so on.

This raises the question whether the authority given under the AP is sufficient for general application. After all, the difference between a non-compliant state and some other state might be simply that undeclared activities have not yet been detected in the latter, and since detection of undeclared activities is a primary purpose of the AP, any shortcomings in the AP could be problematic.

The AP has not been in operation long enough to be able to conclude that it is deficient. The IAEA has considerable flexibility in the way the AP is applied, e.g. in the number of complementary accesses performed – although the provisions specifying the measures that can be implemented during complementary access might prove to be constraining. At this stage however there is no reason to believe the AP is not sufficient for routine cases. If necessary, the Agency has the special inspection provisions to fall back on.

What is a more problematic situation is where a state does not have an AP in place. The IAEA has made it clear that without an AP its ability to draw conclusions on the absence of undeclared activities is limited.

6. CONCLUSIONS

In the last 15 years or so the IAEA has made substantial progress in establishing a capability to detect undeclared nuclear activities. There is good confidence that large-scale activities will be detected, but activities such as small-scale enrichment (e.g. centrifuge installations sufficient to produce one to two significant quantities a year) remain a challenge.

The IAEA's methods use a combination of technical detection techniques and information collection and analysis. Information is especially important – including data the Agency can directly gather for itself (by inspectors in the field or other technical means), data submitted by the state (including, *inter alia*, accountancy data and design information), data the Agency can draw from open sources (including satellite imagery and the application of data-mining techniques), and data supplied to it from third parties (including governments, NGOs and individuals).

On the technical side, more development is needed, and the Agency has a soundly-based R&D program to this end, working with the Member State Support Programmes. As regards information,

10. IAEA Statute, Article XII.A.6.

amending the AP Annexes will be important, to include dual use items and additional non-nuclear materials. Also important is reporting on export denials and procurement enquiries.

The safeguards system cannot counter undeclared nuclear activities by itself, states must be prepared to share national intelligence information. There needs to be a close partnership between safeguards and intelligence – intelligence is vital in identifying locations of interest, and safeguards provide the means to investigate locations, to get “under the roof”. This is not threatening to states – if suspicions are unfounded, it is in everyone’s interest that safeguards operate as an effective mechanism for demonstrating this.

This leads naturally to the issue of cooperation. It is in every state’s interest to cooperate with the Agency – it is notable that a number of cases of poor cooperation have turned out to involve serious safeguards breaches or non-compliance. The international community will draw its own conclusions where states are uncooperative.

A particularly important form of cooperation is the conclusion and implementation of an Additional Protocol. This is essential for all states, but especially for comprehensive safeguards agreement states with significant nuclear activities. At the time of writing, out of 63 such states, 8 had not signed an AP, and 10 had signed an AP but not brought it into force. The IAEA has clearly stated that without an AP its ability to draw conclusions on the absence of undeclared nuclear material/activities is limited.

Finally, expectations about what the IAEA can achieve with regard to undeclared nuclear material/activities need to be realistic. This applies both to the effort the Agency applies to trying to detect these – what is “sufficient” is a matter for expert judgment – and the standard of proof required in determining the significance of undeclared material/activities when found.