Verification of Elimination of Nuclear Weapons and Safeguards of Weapon-usable Materials

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1. Definitions: Weapons-usable materials

- Enriched Uranium
  - over 90% U-235
  - from IAEA's verification viewpoint over 20% U-235

- Plutonium
  - Pu-239
  - Most such claims are based on the assumption that all plutonium mixtures (except if more than 80% Pu-238) are "weapon-usable";
  - the suitability of a plutonium mixture for explosive devices is determined by its Pu-240 content:

Weapon-grade:	< 7 %	*Standard*
Fuel-grade	7-18 %	*Practically usable*
Reactor-grade	> 18 %	*Theoretically usable*

2. Nuclear weapons states: verification challenges regarding disarmament and the world without nuclear weapons

World without nuclear weapons

- long and difficult road
- political, economic, legal, technical and security challenges,
- need to develop approaches, methods and technologies with right balance between security and proliferation concerns and sufficient international verification including access to materials, facilities, information and people

.....

- States and the international community are rich in implementation experience; 60 years and 30 years of NPT
- National systems are being established to generate reliable data and information, to share that with the others and IAEA
- Ethical option and moral obligation; Can be achieved; political will, leadership, resources, processes, structures, activities...

What is meant by “verification”?

- Verification is a "process of gathering and analyzing information to make a judgement about parties' compliance or non-compliance with an agreement.“ Confidence-building is of fundamental import...
- Nuclear warhead dismantlement verification possess some advantages in comparison with other weapons of mass destruction verification
  - Fewer items to declare, monitor, and verify,
  - Fissile material is also relatively scarce compared to chemical or biological warfare agents
- Comprehensive verification scheme is likely to require nuclear-weapon states to grant access to all relevant facilities, a large selection of relevant personnel, and a wide range of documentation.
- However, one factor that facilitates effective and efficient verification is the careful selection of items, activities, and facilities that must be monitored and those that need not be; RSA exp. are encouraging
- Absolute assurrances of compliance is theory; we can live with the remainig uncertainty, if we have proven the reliability of the one ...

Verification design

Adresses basic but non-trivial questions, such as:

- How can inspector be sure that he/she is looking at a nuclear warhead and not a dummy?
- If the inspector cannot observe the dismantlement process, how will he be sure that disassembled parts come from the warhead and not some hidden stash of electronics components?
- How can the inspector be sure that the host state has accounted for all nuclear material if he cannot measure and weigh the "physics package" (the fissile material part)?
- How can the inspector be certain that the state has declared all its nuclear warheads?
- How can the inspector be assured that there is no further undeclared production of nuclear warheads?

Important issues to be solved by verification designers (9-13)

1. The coverage of declarations, access to facilities, materials and people, and how to address situations when access can not be provided.
2. Arrangements that protects inspectors from non-nuclear states from getting access to weapons sensitive information (proliferation risk).
3. ‘Transparency’ is limited, therefore other ways and means shall be developed to obtain required assurances (to prove reliability).
4. Need to develop credible methods and procedures to address appropriately problems in implementation (not to run high risk of bringing evidence of non objectivity and that of incompetence).
5. Safety and security rules and procedures must be respected and efficient inspection procedures must be developed that in mind.
6. Currently operated facilities are not designed international inspections in mind and various constraints and sensitivities will be faced. New facilities however will be build taking into account the requirements enabling efficient verification.

Important issues to be solved by verification designers (1)

The coverage issue:

- Inspection designers need to develop standards for declarations of treaty-limited items along with lists of items, activities, and personnel available for inspection and interrogation.
- Ideally, the right to pick and choose some of these items, activities, and personnel should be firmly established.
- It is likely that an inspection process
  - will not "establish" or "confirm" that a warhead has been dismantled or that all warheads have been declared.
  - is possible to identify and point out a fake weapon with relatively high certainty.
- What can not be covered by inspection need to be addressed in other ways and by other means

Important issues to be solved by verification designers (2)

The legal issue:

A nuclear-weapon state cannot, according to Article I of the 1968 nuclear Nonproliferation Treaty, "assist, encourage or induce" a non-nuclear-weapon state to manufacture a nuclear weapon or other nuclear explosive device.

- How to ensure that non-nuclear-weapon state inspectors access to nuclear weapons and facilities do not receive sensitive information and doesn’t pose serious risks of passing on classified information in their role in the verification regime.

The transparency issue:

Obviously, very much transparency can never be given, making absolute confirmation impossible. Therefore, some degree of uncertainty must be acceptable in verification.

Important issues to be solved by verification designers (3)

The intrusiveness issue:

What constitutes an acceptable levels of intrusiveness?

- Likely to provide only a minimum level of transparency
- From the inspector's point of view, a delay or deferral in access, for example, may be seen as a way to circumvent inspections
- Need to develop procedures and methods for resolving compliance issues involving national security-related facilities and information. These procedures are likely to differ from state to state.

The safety issue:

Safety of the inspectors and the facility staff;

- What restrictions are acceptable and in place to prevent an accidents
- Large quantity of conventional explosives involved even in latest-generation nuclear devices puts restrictions on what equipment the inspectors can bring in, as well as what clothes they should be allowed to wear.

Important issues to be solved by verification designers (4)

The facility design issue:

Regarding existing facilities:

- They were not designed for international inspections and inspectors,
- The host will wish to protect as much sensitive information as possible, while the inspectors will wish to find out the truth.
- Information relating to the mass, configuration, or isotopics of the physics package, exact facility layout linked to various processes, schedules for input and output, and the location and function of security systems will obviously be protected and may hamper effective inspections due to facility design shortages.
- In addition to being a potential security risk, the inspectors' presence will interrupt site operations.
- The facility operator may want to safeguard the anonymity of his or her staff.
- There is a real risk that the host's sensitivities will override the inspector's demands effectively undermining the verification regime.

Important issues to be solved by verification designers (5)

The facility design issue:

Regarding new facilities:

- Design will take into account international inspections and facilitate much more effective inspections while accommodating national security concerns.
- Inspectors could also be invited to conduct design-information verification as the facility is constructed in order to verify the absence of hidden trapdoors, extra piping, valves, or other undeclared construction.

Future Research Agenda (1)

Multinational efforts are needed to develop the approaches, methods and technology needed for verifying disarmament.

At a technical level, research has been suggested to focus on at least the following:

1. Developing a generic model of the entire dismantlement **process**.
   - include all relevant verification objectives and technologies and identify suitable verification procedures for each dismantlement action.
2. Developing a **declaration standard**.
   - should allow the inspected party to list all sites, documentation, and personnel relevant to the verification process. It should include a section describing sites, documents, or personnel not eligible for inspection and for what reasons. It should include an attached description of special safety precautions the inspectorate must take when visiting the facilities.

Future Research Agenda (2)

3. Identifying key **inspection points and associated measurement technologies** and techniques, including information barriers and other restrictions.
   - The IAEA Trilateral Initiative made significant headway in this work (16-20)
4. Developing **procedures** and methods that will help states-parties and the inspectorate resolve compliance concerns involving national security-related facilities and information.
5. **Cost estimates** of building new, identical built-for-purpose dismantlement facilities and comparing these with the costs of using existing facilities with their inherent challenges.

Case study: The Trilateral Initiative 1996-2002

- A six-year (1996-2002) effort to develop a verification system under which Russia and the United States could submit classified forms of weapons-origin fissile material to International Atomic Energy Agency (IAEA) verification and monitoring in a irreversible manner and for an indefinite period of time.
- The initiative sought to broaden the items that could be brought under IAEA monitoring to include any classified items containing plutonium or highly enriched uranium, including nuclear warheads, warhead components, pits, or secondaries.
- Designed to protect classified information and to ensure that both countries met their obligations under Article I of the nuclear Non-proliferation Treaty (NPT).
- IAEA recognized that its access would be restricted.

Four verification levels were considered

Level 1: limit the initiative to accepting only unclassified materials, which would have removed those materials from reuse;

Level 2: accept classified forms of fissile material without attempting to establish that the forms actually represent nuclear warheads or components thereof;

Level 3: verify the fact that the items presented are in fact nuclear warheads or specified components thereof, including specific model identifications; or

Level 4: start with the dismantlement of weapon systems or subsequent stages so that the monitoring could attest to the removal of warheads from delivery systems.

For practical purposes, the parties decided that the initiative should aim for Level 2, which posed significant challenges but was considered to be achievable. Level 1 would not have required a new framework. Going to Level 3 would have presented far greater security concerns and challenges related to authenticating warhead templates that could be used by the IAEA. Level 4 would have been a simple extension of Level 3.

Case study: The Trilateral Initiative 1996-2002

- Participants examined various technical means of verification,
- An attribute verification, which would provide far less information than the IAEA obtains under routine plutonium safeguards, was deemed to be sufficient to be formally accepted
- Attribute verification involves comparing an object to a set of reference characteristics (For example, the presence of a militarily significant quantity of weapons-grade plutonium would be assessed by measures that first determined the presence of plutonium, then assessed that the isotopic composition of the plutonium was such that it was weapons-grade material rather than reactor-grade, and finally calculated that the mass of plutonium fell above an agreed minimum defined in relation to each facility).
- Several measurement methods were identified that could satisfy this requirement.
- The scheme for monitoring and verifying included also use of seals, a perimeter monitoring system, and normal IAEA safeguards methods.

Case study: The Trilateral Initiative 1996-2002

- The initiative developed slowly.
- Nonetheless, by November 2001, Russia and the USA were on the brink of agreeing to a model verification agreement.
- 2002 the two sides had agreed that the initiative should be brought to a close.
- From a legal perspective, the Trilateral Initiative was ready at that point to be carried out, although some implementation details still required further negotiation.

Case study: The Trilateral Initiative 1996-2002

The final report in 2002:

- “Over the course of six years, the Joint Working Group addressed the technical, legal and financial issues associated with implementing IAEA verification of weapon-origin and other fissile material released from defence programmes and can now recommend the successful completion of the original task. The enabling technologies developed under the Initiative could be employed by the IAEA on any form of plutonium in nuclear facilities, without revealing nuclear weapons information. The Working Group found no technical problem that would prevent the IAEA from undertaking a verification mission in relation to such fissile materials released from defence programmes, and believes that many of the technical approaches could have broader applicability to other forms of fissile materials encountered in conjunction with nuclear arms reductions.”
- In addition, verification arrangements essentially were agreed on for initial implementation at the Fissile Material Storage Facility at Mayak in Russia and at the K-Area Material Storage (KAMS) Facility at the Savannah River site in the United States.
- If so wished, the Initiative could be reactivated.

3. Non-nuclear weapon states: verification challenges regarding non-proliferation of nuclear materials from civil purposes

Verification will face inevitable changes (1)

- With respect to the IAEA safeguards and verification, the main future challenges include
  - expanding use of nuclear energy
  - fast globalisation of the nuclear supply chains, and
  - the fate of the NPT; Result of the Review Conference 2010.
- If the world economy grows on long term as now predicted, energy needs will grow faster than supply.
- New nuclear facilities are constructed, old ones modernized,
- Amounts of nuclear material and sensitive knowledge are growing and spreading.
- Nuclear supply chains and trade are expanding.

Verification will face inevitable changes (2)

- Modern business models of nuclear related industries already include company activities and actors all over the world.
- Countries having no previous safeguards infrastructure or experience are planning to embark on nuclear.
- Bottlenecks in the nuclear manufacturing and fuel services may appear, which can lead to national interests to master nuclear fuel cycle services thus possessing new risks for non-proliferation.
- Expanding safeguards operational environment is not only technical; it has political, economical, industrial and social dimensions that are interconnected and must be taken into account.
- Resources of the National Systems of safeguards and material security are not necessarily adequate taking into account the new challenges, including these IAEA is facing.

IAEA Verification Standard

- IAEA verification standard; the safeguards system is based on the measures of the comprehensive safeguards agreement and the additional protocol.
- Nuclear material accountancy measures are complemented with measures to establish and maintain coherent picture about the nuclear activities and materials in a state.
- The evaluation results of inspections and information will determine the approaches implemented in a given state.
- Establishment and maintenance of initial inventories of and confidence on the state party to the safeguards agreement are providing the initial prove for the reliability.
- Negotiated routines are providing for cost efficient implementation, and in case IAEA is unable to assure itself about the compliance...
- Special inspection may be carried out to obtaine the re-assurrances or to detect non-compliance.

Organization structure, processes and resources to match with enhanced role and responsibilities

- New expectations and experiences need still to be incorporated to a coherent implementation praxis: Uniform effective criteria, methods, processes and practices, or double-, triple-standards exists, but are not universally accepted and used. Re-engineering is underway.
- Organization is currently under stress. The expectations are high, resources are not adequate. - Additonal, high calibre staff is needed.
- IAEA's resources are unlikely to increase in the same pace with increasing verifications activities implying that
  - focus will be more on information driven verification activities, thus running a risk of diverting attention from the basic nuclear material accountancy.
  - Use of state-of-the-art technologies diverts the management attention to associated 'problems' and away from interactions that are aimed at proving the reliability of the state system, like negotiations.
  - Also under such resource constrains staff can not adequately participate in for example research and development activities, which brings along a risk of being driven by the technology.

Implementation: Verification culture needs to change (2)

- With its expanding workload productivity requirements will also get higher, efficiency of administration will be in focus, efforts made finding synergies (with other regimes) and setting priorities - Giving up tasks proven valuable?
- Transparency, negotiation and cooperation with States, importance of competent, strong and independent regulatory body (safeguards, safety and security).
- Member States and the Secretariat transferring safeguards knowledge to those embarking on nuclear and/or developing their national regulatory systems.
- Nuclear vendors embedding safeguards features directly deep into their facility designs, systems and components will play important roles.

Also other safeguards innovations are needed

- 4th generation reactor systems,
- Development and implementation of international nuclear fuel cycle regime: IAEA's "Multilateral Approaches to the Nuclear Fuel Cycle". No need for single state
    - to enrich uranium
    - to reprocess spent fuel; taking back spent fuel
- New verification technologies, advanced sensors.
- Increased use of simulation and modelling.
- Handling the data and information flows.
- Better use of best practices and SSAC/RSAC.

Multilateral options

Whether for uranium enrichment, fuel reprocessing, or spent fuel disposal and storage, MNA options span the whole spectrum beyond existing market mechanisms and up to co-ownership:

1. **Type I**: **Assurances of services not involving ownership of facilities**:
    a) *Suppliers provide additional assurances of supply.*
    b) *International consortia of governments.*
    c) *IAEA-related arrangements.*
2. **Type II**: **Conversion of existing national facilities to multinational facilities**
3. **Type III**: **Construction of new joint facilities.**

Main conclusions

- Trust and Verification: long term commitment is recuired.
- Political, diplomatic, legal and technical challenges to be faced.
- Need to develop approaches, methods and technologies with right balance between security and proliferation concerns and sufficient international verification including access to materials, facilities, information and people.
- Organizations to be re-engineered and cooperation practices tuned to support the development, negotiation and implementation efforts.
- States have to take into account changing circumstances:
  - Long-term growth in nuclear power,
  - Globalization of nuclear industry and supply chains, technology transfer,
  - Political will; mastering whole fuel cycle, expansion of enrichment techs.
  - Growing number of “virtual nuclear weapon states”.

Non-proliferation and elimination of nuclear weapons are obligations that need to be undertaken now. An opportunity is offered to develop a new security culture where confidence-building will play a central role, deficiencies are recognized and taking care of, doings causing undesirable consequences avoided. Protection provided by the ‘good faith’ is ensured.