



Verification

Theory, practice and technologies

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Outline

1. Verification, monitoring and compliance.
2. Principles of verification.
3. Indicators, signatures and detectors.
4. Nuclear disarmament.
5. Verifying dismantlement.
6. Gazing into the crystal ball.



Part 1:

Verification, monitoring and compliance

Dictionary definitions

- **Verification:** the process of establishing the truth, accuracy, or validity of something.
- **Monitoring:** to observe and check the progress or quality of (something) over a period of time.
- **Implementation:** the process of putting international law into effect.
- **Compliance:** the state or fact of according with or meeting rules or standards.

A simple example

- **The rule:** ‘Country A’ shall not deploy any armed forces within 50 kilometres from the border of ‘Country B.’
- **The implementation:** ‘Country A’ issues standing orders to all its armed forces prohibiting the deployment of any armed personnel, any combat vehicles or standing installations, and the conduct of any aerial manoeuvres in an area extending 50 kilometres from the territorial borders of ‘Country B.’

A simple example (continued)

- The rule: ‘Country A’ shall not deploy any armed forces within 50 kilometres from the border of ‘Country B.’
- The compliance: a simple binary question. ‘Country A’ is in compliance if there are no armed forces within 50 kilometres of the border of ‘Country B’. It is in non-compliance if there are armed forces within this area, no matter for how long.

A simple example (continued)

- **The rule:** ‘Country A’ shall not deploy any armed forces within 50 kilometres from the border of ‘Country B.’
- **Monitoring:** Country B operates a radar station that can detect aeroplanes operating within 50 kilometres of its borders (a ‘national technical mean’). It also receives satellite imagery, in visual and infrared ranges, of the border area from an ally (also a ‘national technical mean’). The United Nations has a small unit of military observers patrolling the area on foot and with vehicles (‘multilateral monitoring’).

A simple example (continued)

- **The rule:** ‘Country A’ shall not deploy any armed forces within 50 kilometres from the border of ‘Country B.’
- **Verification:** As of 17 March 2017 at 10:00 am, are there any Country A forces within 50 kilometres of the border of Country B?
 - The radar sees nothing.
 - There is nothing on the satellite imagery.
 - The UN military observer team has seen nothing.
 - It is *unlikely* than not that there are Country A forces deployed.

A simple example (continued)

- **The rule:** ‘Country A’ shall not deploy any armed forces within 50 kilometres from the border of ‘Country B.’
- **Compliance determination:** As of 17 March 2017 at 10:00 am, Country A is *likely* to be in compliance with the rule.

Some simple observations:

- You verify compliance with a rule.
- Monitoring is a sub-set of verification, but can, of course, occur even if there is no rule to verify compliance against (the radar station and the satellite images).
- Verification often takes into account several data streams (the radar station, the satellite imagery and the UN mission).
- You are rarely able to have 100% confidence in your monitoring. What if Country A forces move forward under cover, or in areas where there are gaps in surveillance?
- A compliance determination is often temporal.

Some simple observations (continued):

- Implementation is necessary, as it allows one party – in this case Country B – to instruct and authorize national authorities (the armed forces) to conduct action in support of an international agreement.
- Neither implementation nor verification guarantees compliance, simply facilitates and monitors it. It gives parties some assurances that international obligations are being followed.

Compliance problem:

- Consider the case where Country A forward-deploys an armed force, equipped with armored personnel carriers. This is detected by observers and international technical means. Country A claims these units are armed police forces, required for the maintenance of public order.
- A compliance question. Are police forces covered by the agreement?

Implementation problem:

- Notwithstanding the order not to enter the 50 km area, some of Country A's armed forces have misinterpreted the order or have been issued outdated maps. They venture into the area and stay there for a time. When the mistake is discovered, they are ordered to withdraw. They were detected by national technical means and by the monitors.
- Also a compliance question. How to deal with 'unforced errors' of this kind?

Verification problem:

- Consider the case where satellite imagery acquired from Country B indicates that some forces have forward deployed, but there are no reports from UN observers or other technical means of verification.
- In reality, County A did not forward-deploy.
- This is known as a false positive, or the ‘crying wolf’ scenario.

Verification problem:

- Consider the case where neither national technical means nor the UN observers have noticed anything unusual along the border.
- In reality, County A has forward-deployed.
- This is known as a false negative, sometimes referred to as a ‘false sense of security.’

Even low detection rates can deter, but...

- Assume that national and international monitoring have a 5% detection probability for each day Country A forces remain forward-deployed.
- Also, assume that 'A' forces must remain in the 50-kilometre zone for a minimum of 20 days to prepare for an assault.
- Conclusion: There is a 1 in 1.6 probability that Country A forces will be detected by the end of 20 days; there is a 1 in 3 probability that Country A forces will remain undetected.

... is that enough?

- Assume that Country B will be defeated if 'A' surprise attacks. The survival of the state is dependent on the verification system.
- Also, assume that Country A is most likely defeated if Country B detects their preparations within the 20 day period.
- To achieve a 99% probability of detection over a period of 20 days, the verification regime must have a 20% probability of detecting a Country A forward-deployment every day.

Effective verification

In other words, effective verification depends on detection probability, consequences of non-compliance, and options for effective response.

“... if the other side moves beyond the limits of the treaty in any militarily significant way, we would be able to detect such violation in time to respond effectively and thereby deny the other side the benefit of the violation.”

Paul Nitze, Special Advisor to President Reagan and Secretary of State on Arms Control.



Part 2:

Principles of verification

Principles of verification

- Principle 1: Adequate and effective verification is an essential element of all arms limitation and disarmament agreements.
 - Is this true in the Country A-B example?
- Principle 2: Verification is not an aim in itself, but an essential element in the process of achieving arms limitation and disarmament agreements.
 - Is this true in the Country A-B example?
- Principle 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.
 - Did the verification regime serve this purpose in the Country A-B example?

Principles of verification

- Principle 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.
 - It did so in the Country A-B example.
- Principle 5: Verification in the arms limitation and disarmament process will benefit from greater openness.
- Principle 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.
 - Compare with the example of clandestine forward deployment in the Country A-B example.

Principles of verification

- Principle 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.
 - Could have been useful in the Country A-B example. How to implement?
- 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, time-frames for such reviews should be agreed in order to facilitate this assessment.
- Principle 9: Verification arrangements should be addressed at the outset and at every stage of negotiations on specific arms limitation and disarmament agreements.
 - Critically important point, so often ignored in international negotiations.

Principles of verification

- Principle 10: All States have equal rights to participate in the process of international verification of agreements to which they are parties.
- Principle 11: Adequate and effective verification arrangements must be capable of providing, in a timely fashion, clear and convincing evidence of compliance or non-compliance. Continued confirmation of compliance is an essential ingredient to building and maintaining confidence among the parties.
 - Compare the Country A-B example and the Nitze definition of effective verification.
- Principle 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.

Principles of verification

- Principle 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.
- Principle 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.
- Principle 15: Such requests should be used only for the purposes of the determination of compliance, care being taken to avoid abuses.
 - Abuses in the Country A-B scenario could be to request access to armed forces just to assess their strength and capabilities. Not covered by the agreement.

Principles of verification

- Principle 16: Verification arrangements should be implemented without discrimination, and, in accomplishing their purpose, avoid unduly interfering with the internal affairs of State parties or other States, or jeopardizing their economic, technological and social development.
 - What if the UN monitoring group, in the Country A-B example starts to provide information on other aspects of Country A's development?



Part 3:

Indicators, signatures and detectors

Basics

- **Indicator:** a thing that indicates the state or level of something. For instance, if an agreement puts a cap on the numbers of weapons legally allowed, the total weapons count would be the indicator.
- **Signature:** a distinctive pattern, product, or characteristic by which someone or something can be identified. For example, if the agreement focuses on 'main battle tanks', the physical characteristics of the vehicle (length, weight and that it has a mounted heavy weapon) would be the signature.
- **Detector:** a device or instrument designed to detect the presence of a particular object or substance. A piece of technology, like an airborne camera that captures the main battle tank's signature.

Specific example

- Paragraph 28: “The Agreement should provide that the objective of safeguards is 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, **and** deterrence of such diversion by the risk of early detection.” (Source: IAEA 'Comprehensive Safeguards Agreement', INFCIRC/153, June 1972.)
- A lot to unpack:
 - **Object:** "Nuclear materials." The metals uranium, plutonium, and thorium.
 - **Quantity:** Eight 'effective' kilogrammes of plutonium, eight kilogrammes of U-233 or 25 kilogrammes of U-235.
 - **Timely detection:** Not defined in the agreement, but usually in the 'order of days' (a week to 10 days).
 - **Diversion:** the undeclared removal of declared nuclear material or undeclared production.

Specific example: what is the indicator?

- Indicator: a thing that indicates the state or level of something. For instance, if an agreement puts a cap on the numbers of weapons legally allowed, the total weapons count would be the indicator.
- Example: A site declares that it has 1,000 kilogrammes of uranium enriched to five percent in the isotope 235 (that is 50 kilos of uranium-235) and that it stored in a sealed room in a identified warehouse.
- The total mass of uranium is the indicator. For instance, if it is below the declared value, it could point to a diversion. Another indicator could be the status of the seal: has it been tampered with? If so, have materials been removed or introduced between inspections?

Specific example: what is the signature?

- Signature: a distinctive pattern, product, or characteristic by which someone or something can be identified.
- Example: A site declares that it has 1,000 kilogrammes of uranium enriched to five percent in the isotope 235 (that is 50 kilos of uranium-235) and that it stored in a sealed room in a identified warehouse.
- You cannot distinguish two isotopes by simply looking at the metal. You would need to measure it to get the 'isotopic ratio.' Gamma rays have well-defined energies that are characteristic of the isotopes emitting them. Therefore, a gamma spectroscopy measurement would give you this. The emission is the signature.

Specific example: what is the detector?

- Detector: a device or instrument designed to detect the presence of a particular object or substance.
- Example: A site declares that it has 1,000 kilogrammes of uranium enriched to five percent in the isotope 235 (that is 50 kilos of uranium-235) and that it stored in a sealed room in a identified warehouse.
- The inspector could conduct the measurement with a ‘miniature multichannel analyser’ combined with a sodium iodide (NaI) detector and portable computer.
- The inspector can visually inspect the status of any applied seals.
- The inspector can use a scale to weigh the material.

What's the takeaway?

- In this case: in order to verify non-diversion, the IAEA needs to conduct 'material accountancy' (weighing and measuring the material) combined with a check of the integrity of the 'containment' (that is the seals applied).
- When all measurements and checks are complete, they will know the weight of the uranium-235 contained in the store. They can then compare that with the facility's own records to assess whether everything has been accounted for.
- But the methods and technology used is unique to the item being verified.
- You need to know what to look for, what to verify, before you can answer questions such as who, when, how, and with what?

Lots of technology available ...

- Many view space-based assets (satellites) as a fundamental tool in the verification and monitoring toolbox.
 - This technology is becoming cheaper and more readily available.
 - In visual ranges, the resolution is constantly improving.
 - Several technologies can be deployed on the platform; imagery (such as visual or infrared), radar, gravimetric sensing, and so forth.
- Aerial sensors are also deployed. Various sensors, such as cameras, radars, gravimetric devices, and radionuclide sensors can be mounted on an airframe.
- Ground-based detectors are very common. They range from 'Eyeball Mk. I' (peacekeepers at observation posts) to equipment deployed in on-site inspections (handheld or stationary sensors such as closed-circuit television or gamma spectrometers), Requires access to the area observed.

...but cannot always be used

- Space-based assets are not useful in our accountancy example. Can measure isotopic and verify seal integrity from a satellite.
- Aerial sensors are not useful in our accountancy example. Can measure isotopic and verify seal integrity from a plane.
- Ground-based detectors are useful in our example.
- Your choice of technology depends on the object under examination, compare with principle 12 of the principles of verification.

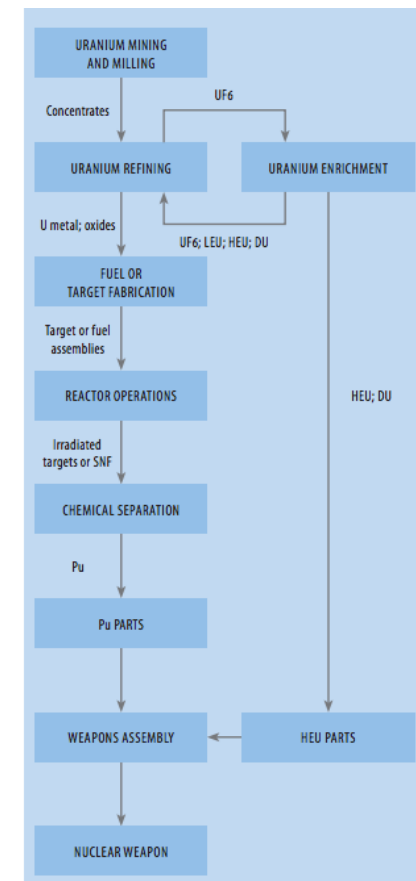


Part 4:

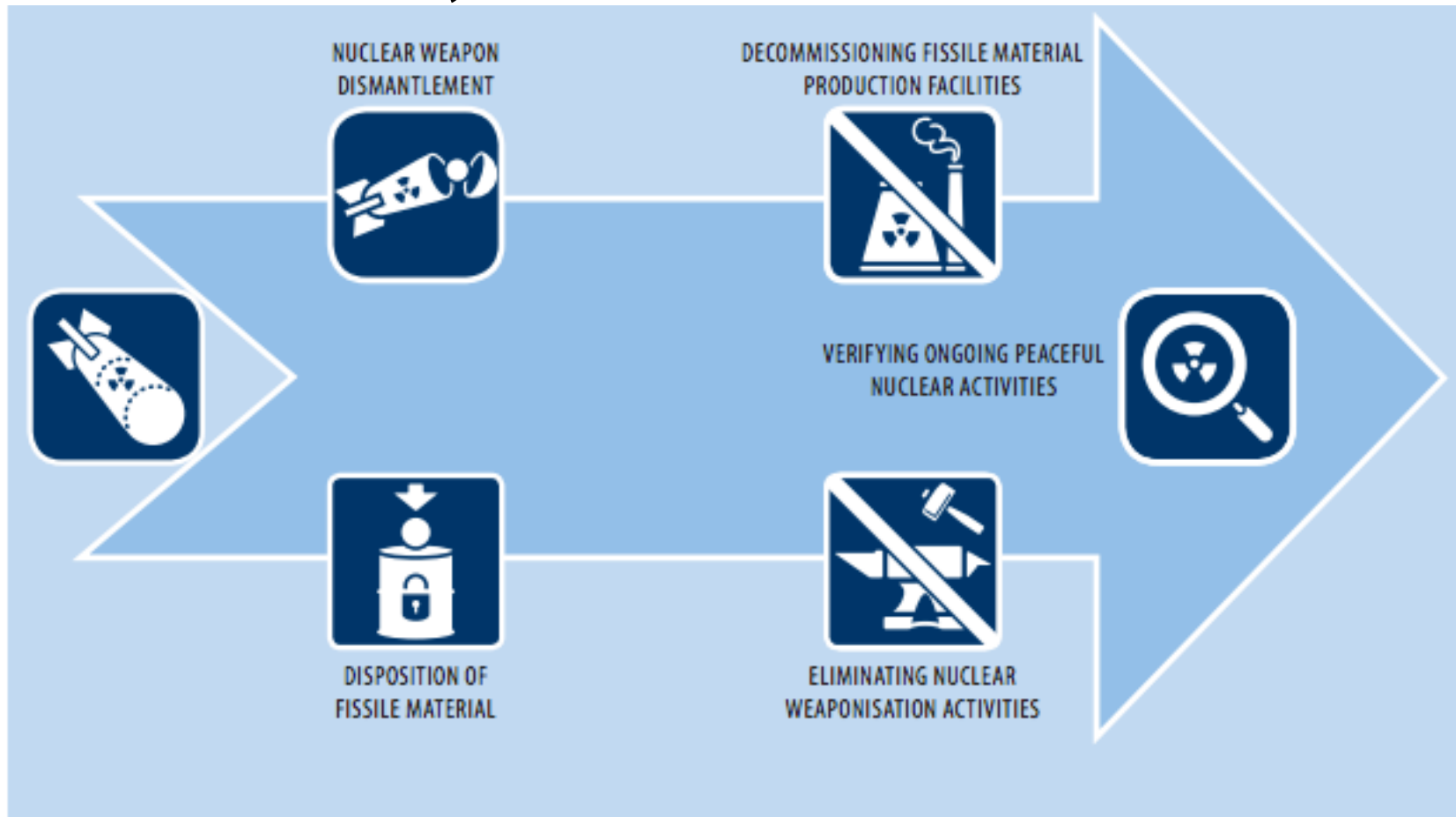
Nuclear disarmament

What to verify depends on assumptions

1. Verifying total abolition will require a broad set of verification options, relating to the reduction of the number of weapons, the disposition of nuclear materials, and the monitoring designed to prevent the re-emergence of nuclear weapons.
2. If the focus is on reducing weapons-usable fissile material, you would need to consider a disposition scheme, and accompanying verification arrangements.
3. If your focus is on reducing the numbers of weapons, but not necessarily disposing of nuclear materials, you would need to think about verification arrangements monitoring dismantlement processes.



What to verify



Abolition: what's in the box?

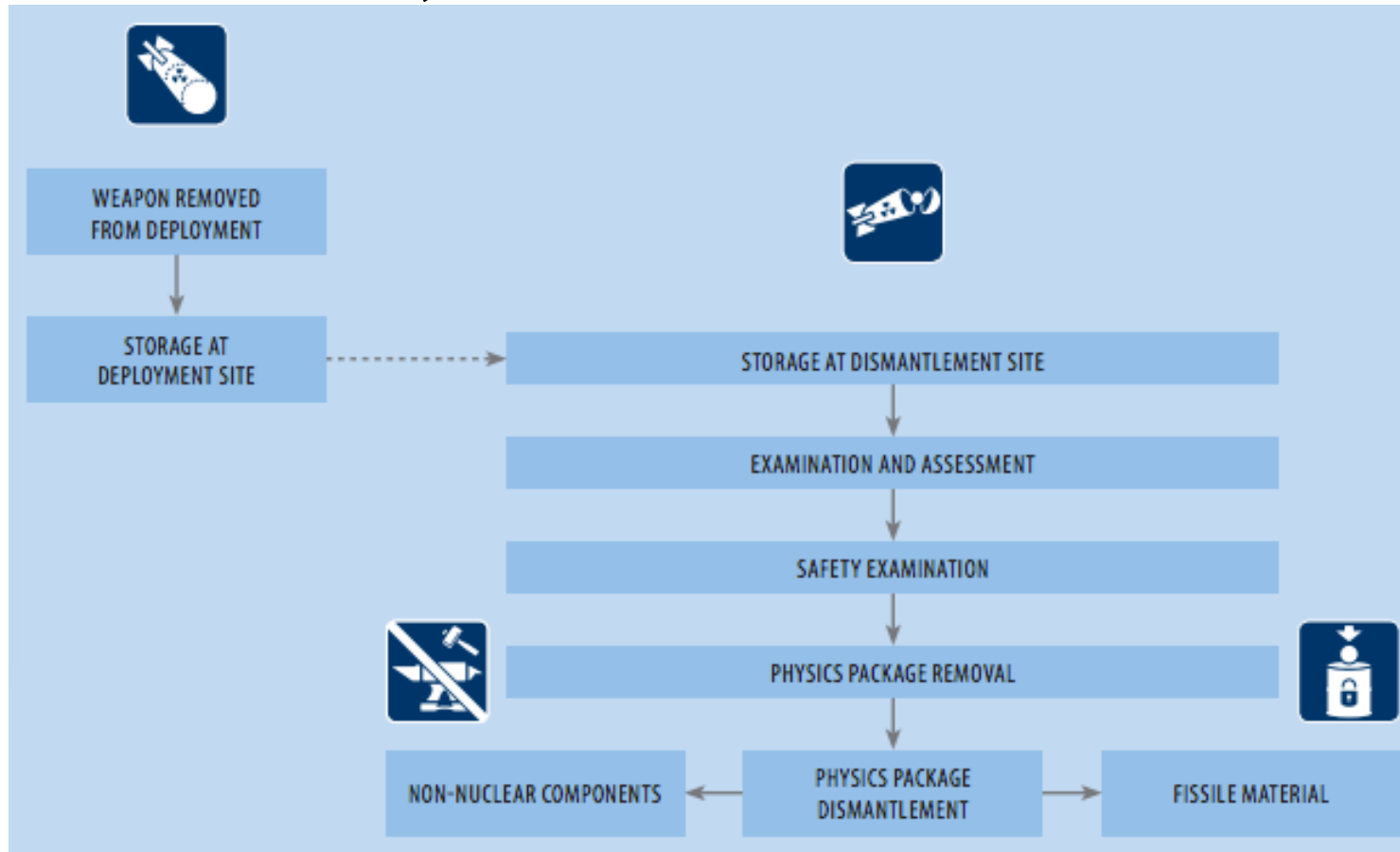
- The disposition of nuclear materials was considered by the so-called 'Trilateral Initiative,' a collaboration between the International Atomic Energy Agency, the United States and Russia.
- The Plutonium Management and Disposition Agreement (PMDA), also suspended, have considered disposition questions.
- Verifying on-going peaceful nuclear activities can be covered through an adaptation of existing IAEA safeguards rules. It will be necessary to develop state-level measures applied to the former nuclear weapon state.
- While work is on-going in several informal fora, there is very little consensus on how to conduct verification activities focusing on the act of dismantling weapons.



Part 5:

Verifying dismantlement

What to verify



Dismantlement: what's in the box?

- How to make nuclear explosive devices is one of the most heavily guarded secret of the nuclear age.
- How do you devise a verification regime examining an object that you are legally required to know very little about?
- Some things are known: the device contains either uranium or plutonium in a certain quantity and with a certain isotopic quantity (sometimes referred to as 'weapons grade' material).
- At the core of the weapon resides a mixture of nuclear and non-nuclear components (the material itself, detonators and high explosives) together referred to as the 'physics package.'

Part 6:

Gazing into the crystal ball

Horizon: 2017-2025?

- Non-nuclear weapon states will soon come together to negotiate a ‘ban treaty’ – but this is not expected to address verification (compare with verification principle 1).
- Is there any scope for the US Trump Administration to revitalise arms control with the Russian Federation? It’s still early days, but there is nothing that gives rise to optimism.
- What about European attitudes to nuclear arms control in the meanwhile? Is there any scope for further reductions in French or UK arsenals?
- What about prospects for South Asian arms control?

Horizon: 2025-2050?

- It is extremely difficult to forecast the political outlook far ahead of time.
- However, given the rapid evolution in conventional arms, as well as new and emerging technologies (such as all-things-quantum), what role for a then 100-year-old weapons system? Will we view them as we today view the role of cavalry during the First World War?
- The investment trend would indicate that major nuclear powers have deprioritised their arsenals, in favour for increased conventional capabilities. However, the marginal cost to establish a nuclear weapons programme is decreasing, reducing the barriers to entering the nuclear club. Therefore, the long-term outlook still points to the need to strengthen verification capabilities in regards to nuclear disarmament overall.

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