"PEACEFUL" NUCLEAR PROGRAMS AND THE PROBLEM OF NUCLEAR LATENCY

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The views in this paper are the author's and not necessarily those of NTI.

1. INTRODUCTION

This paper discusses issues involved in assessing the risk of proliferation from national nuclear programs, in particular whether criteria could be established for assessing if an ostensibly "peaceful" program is really aimed at developing nuclear weapons. The paper originally appeared under the title *Assessing and Minimising Proliferation Risk*, as a chapter in the book *Limits to Secure Nuclear Tolerance*, published by the International Luxembourg Forum, Moscow, in 2014.[1]

With the recent conclusion of the Joint Comprehensive Plan of Action (JCPOA)[2] for Iran's nuclear program, it is timely to update the paper to take account of this important development. The JCPOA is an unprecedented effort to reduce international tensions arising from a national nuclear program. However, the JCPOA does not in itself resolve the underlying problem: how to ensure that national programs in enrichment and/or reprocessing do not result in the proliferation of nuclear weapons. If at the end of the JCPOA's 15-year limitation period Iran proceeds with plans to expand its enrichment program by orders of magnitude[3], the international community will face this problem all over again. It is essential to use the time provided by the JCPOA productively to reach a lasting solution to this problem.

This paper addresses major underlying themes relating to national nuclear programs, in particular the boundaries of "peaceful uses" permitted by the Nuclear Non-Proliferation Treaty (NPT), and the closely related issues of *nuclear latency* and *nuclear hedging*. The paper also looks at the safeguards challenges presented by national nuclear fuel cycle developments, and the effect of these on the ability of the IAEA (International Atomic Energy Agency) safeguards system to meet the expectations reflected in the NPT.

With respect to criteria for assessing "peaceful" nuclear programs, the paper considers:

(a) the risk factors to be taken into account in developing such criteria;
(b) how such criteria might be applied;

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1. http://www.luxembourgforum.org/eng/Forums_Library/items/Book%20by%20VVK%202014_eng.pdf
2. http://www.eeas.europa.eu/statements-eeas/docs/iran_agreement/iran_joint-comprehensive-plan-of-action_en.pdf
3. Iranian spokesmen have indicated plans for an enrichment capacity of 1 million SWU (*separative work units*), 200 times that allowed under the JCPOA:
http://english.farsnews.com/newstext.aspx?nn=13940507001415&mkt_tok=3RkMMJWWfF9wsRoguaTMZKXonjHpfsX54uopXaOg38431UFwdcjKPmjr1YYIScJ0aPyQAgobGp5I5FEIQ7XYTLB2t60MWA%3D%3D

(c) whether a criteria approach is sufficient to deal with proliferation risk.

The very fact of discussing criteria for assessing the *peacefulness* of nuclear programs illustrates a critical change in the dynamics of proliferation. Until recent years, the proliferation challenges that have arisen from states within the NPT have been based on clandestine (*undeclared*) nuclear programs with little or no direct link to declared, safeguarded civil programs. Criteria would have limited utility in addressing secret programs. However, the Iranian situation shows that circumstances are changing – proliferation risk is no longer limited to clandestine programs. Iran, having had to bring under safeguards a nuclear program which it was developing in secret, now maintains that the NPT gives any party the right to develop any aspect of the nuclear fuel cycle.

Iran's actions raise the spectre of *safeguarded proliferation* – that a "peaceful" nuclear program operated under IAEA safeguards could, if and when the state so decides, be used for break-out to nuclear weapons production. If states believe this is the underlying reason for the nuclear programs of other states, international trust and confidence will be undermined, and the credibility of the NPT and IAEA safeguards will be damaged. As will be discussed, the development of criteria could help define the limits of what is internationally acceptable in national nuclear programs.

2. PROLIFERATION RISK – TECHNICAL AND POLITICAL FACTORS

In order to develop criteria for assessing whether the purpose of a nominally peaceful nuclear program might really be nuclear weapons development, it is necessary to look at technical aspects, particularly *capability*, and political aspects, particularly *motivation*. Capability involves questions of fact and can be readily assessed on an objective basis. While motivation is commonly perceived as involving *subjective* considerations, this too can be analysed objectively based on factual indicators.

A. Capability to produce nuclear weapons

Broadly speaking, a nuclear weapon program will involve the following key elements:

(i) Acquisition of fissile material

Fissile material is a convenient term for the nuclear materials required to produce nuclear weapons[4] – principally highly enriched uranium (HEU) and separated plutonium. Production of fissile material requires:

(a) a uranium enrichment plant. While the reason a state gives for acquiring an enrichment plant may be production of low enriched uranium (LEU) fuel, there is no inherent technical barrier to using any of the currently established enrichment technologies to produce HEU. Centrifuge facilities in particular are readily adaptable for HEU; or

4. The term used for IAEA safeguards purposes is *unirradiated direct-use material*.

(b) a reprocessing plant, together with a source of suitable spent fuel. If a state intends to establish a nuclear weapon option, it will install reactors that can be readily used to produce low burn-up fuel (i.e. fuel in which the plutonium predominantly comprises the isotope Pu-239[5]), such as on-load refueling reactors, large "research" reactors, or fast breeder reactors.

Acquisition by transfer While historically nuclear weapon programs have been based on a national capability to produce fissile material, it should not be overlooked that fissile material may also be *imported*:

(a) by legitimate transfer, e.g. research reactor fuel, critical assembly fuel or MOX (mixed-oxide) fuel); or
(b) by illicit procurement, e.g. purchase on the black market or by theft/seizure.

Some research facilities (reactors or critical assemblies) may have comparatively large inventories of fissile material, making them an attractive source of nuclear material for weapons. This risk has been recognized for HEU, and there is a longstanding international program to reduce civil HEU inventories through repatriation to the originating states. To date however separated plutonium has not been given the same attention, and inventories of separated plutonium are increasing in several states.

(ii) Nuclear weaponisation

Weaponisation is a shorthand term for the range of activities, additional to acquisition of fissile material, necessary to produce a nuclear weapon. These include: nuclear weapon design and associated modelling and calculations; high-explosive lenses and implosion testing; specialized high-energy electrical components; high-flux neutron generators; and design and testing of warhead re-entry vehicles. Under the heading *Activities which could contribute to the design and development of a nuclear explosive device*[6], the JCPOA sets out a list of such activities. While the JCPOA is not intended to set a precedent, this list could provide general guidance:

- designing, developing, acquiring, or using computer models to simulate nuclear explosive devices;
- designing, developing, fabricating, acquiring, or using multi-point explosive detonation systems suitable for a nuclear explosive device; unless approved (by the Joint Commission) for non-nuclear purposes and subject to monitoring;
- designing, developing, fabricating, acquiring, or using explosive diagnostic systems (streak cameras, framing cameras and flash x-ray cameras) suitable for the development of a nuclear explosive device, unless approved ... for non-nuclear purposes and subject to monitoring;
- designing, developing, fabricating, acquiring, or using explosively driven neutron sources or specialized materials for explosively driven neutron sources.

5. *Weapons grade* plutonium is commonly defined as comprising 93% or more Pu-239; by comparison, plutonium in spent fuel from the normal operation of a power reactor typically comprises around 55% Pu-239.
6. JCPOA, Annex I, Nuclear-related measures, section T, paragraph 82.

Many of the activities, items and materials involved are *dual-use*, i.e. taken in isolation they do not necessarily indicate an intention to manufacture a nuclear weapon. Some, but not all, involve items on the Nuclear Suppliers Group (NSG) dual-use list. While the purpose of a single dual-use activity may be ambiguous, however, a combination of such activities may more clearly indicate the existence of a nuclear weapon program.

An essential question, in assessing the significance of apparent weaponisation activities, is whether the state is known to have fissile material, or the capability to produce it, but in itself this is not necessarily conclusive. It is possible that detection of weaponisation activities may be the first indicator that a state already has an undeclared (and so far undetected) program to produce fissile material – or weaponisation activities may indicate that a state intends to divert safeguarded fissile material in the future.

(iii) Nuclear-capable delivery system(s)

While nuclear weapons could be delivered by unconventional means, e.g. truck, fishing boat or shipping container, these are really only of terrorist interest. Credible nuclear deterrence requires a delivery system that will perform reliably and has a high probability of avoiding interception. In view of the vulnerability of aircraft, ballistic missiles are the preferred delivery method. Hence, discovery that a state has a ballistic missile program will be a warning sign. Given the substantial costs and accuracy limits of ballistic missiles, development of such missiles may well indicate an intention to deploy highly destructive warheads.

An indication of relevant capabilities is given by the *Guidelines for Sensitive Missile-Relevant Transfers* under the Missile Technology Control Regime, i.e. missiles with a range exceeding 300 kilometers and a payload exceeding 500 kilograms. A state developing missiles exceeding these parameters is not necessarily seeking a nuclear capability (e.g. it may say it is engaged in *space research*), but such development will be grounds for suspicion, especially where other indicators are present, e.g. apparent weaponisation activities, safeguards violations, and so on.

B. Motivation to acquire nuclear weapons

There are several reasons why states might pursue nuclear weapons, including notions of prestige and national pride, the desire to exert influence over other states, or the need for a military deterrent. While these are political sentiments, they can be given tangible form through statements made, actions taken, and so on. In analytical terms, motivation reflects the circumstances of the state, a stimulus or incentive that induces a government to act in a certain way. These circumstances will have factual manifestations, therefor they can be identified and assessed by objective means.

The principal indicator for motivation is the state's strategic environment, e.g.:

(a) is the state located in a *region of tension*?
(b) is it – or does it consider itself to be – under military, economic, cultural or religious threat?
(c) is it involved in military or political confrontation with other states?

The clearest example of a region of tension is the Middle East, and it is no coincidence that of the six safeguards non-compliance cases that have occurred to date, four have involved states in the Middle East.[7] Other areas generally considered as regions of tension are the Korean Peninsula[8] and South Asia.

An important factor may be whether a state is involved in military alliances. Two examples of current relevance are the Republic of Korea (ROK) and Japan. Their alliances with the United States are of critical importance in meeting threats presented by the DPRK (Democratic People's Republic of Korea). Alliances can reduce the motivation to pursue nuclear weapons – and also, through oversight by the alliance partner, can reduce the opportunity to do so.

3. PEACEFUL USES UNDER THE NPT

The use of nuclear energy for peaceful purposes is one of the three fundamental pillars of the NPT, together with nuclear disarmament and non-proliferation. A key objective of the NPT is to ensure that nuclear energy is indeed used only for peaceful purposes and does not contribute to the proliferation of nuclear weapons. Accordingly, Article IV of the NPT affirms the right of states to use nuclear energy for peaceful purposes, provided this is in conformity with the non-proliferation obligations of the Treaty and IAEA safeguards are applied to verify fulfilment of these obligations.

It is notable that the NPT does not define *peaceful purposes* and *peaceful uses*. The Treaty contemplates three categories of nuclear activity:

(a) the manufacture or other acquisition of nuclear weapons or other nuclear explosive devices, or control over such weapons or explosive devices;

(b) non-proscribed non-peaceful purposes, i.e. non-explosive military purposes such as naval propulsion reactors – these activities are not mentioned expressly but are implicit in the wording of the safeguards article (Article III);

(c) peaceful uses and peaceful purposes – these would appear to encompass anything outside (a) and (b).

Iran, in particular, has been very vocal in asserting that Article IV gives it a right to undertake enrichment or any other fuel cycle activity. Article IV however does not refer to any specific technology, but rather, more broadly, to the use of *nuclear energy*. As noted above, this right is not unqualified, but it must be exercised in conformity with the Treaty and for *peaceful purposes*.

The lack of a clear definition of *peaceful purposes* leaves a grey area with respect to nuclear latency and nuclear hedging, problems which were neither adequately foreseen nor appropriately addressed at the time the NPT was negotiated. As will be discussed, international

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7. Iraq, Iran, Libya and Syria. Libya, while not part of the Middle East geographically, is closely involved politically. The other states found in safeguards non-compliance are Romania (former regime) and the DPRK.
8. And North Asia more broadly is looking increasingly fraught.

efforts to minimise proliferation risk must include careful consideration of how the NPT should be applied in contemporary circumstances.

4. NUCLEAR LATENCY AND NUCLEAR HEDGING

A. Nuclear latency

Nuclear latency refers to the situation where a state has established, under a peaceful nuclear program, dual-use capabilities that *could* be used for the production of nuclear weapons. Nuclear latency might be *inadvertent*: e.g. while a state with enrichment and/or reprocessing capabilities thereby has the basic capability to produce fissile material for nuclear weapons, the state may well have (at least in foreseeable circumstances) no intention of doing so.

On the other hand, nuclear latency could also be deliberate – a state could establish enrichment or reprocessing capabilities with an eye to having an essential component for a nuclear weapon option should its strategic circumstances change at some future time. The problem is, it is difficult to tell what the state's intentions may be. From a non-proliferation perspective, the fewer national programs there are in enrichment and reprocessing, the better, and *vice versa* – the more widespread these capabilities become, the greater the risk of proliferation.

While the greatest concern with respect to latency is the establishment of enrichment or reprocessing capabilities, it should not be overlooked that there are other pathways to nuclear latency. One is producing and stockpiling low burn-up fuel, e.g. through operating on-load refueling reactors, large research reactors, or fast breeder reactors. Compared with the difficulty of developing uranium enrichment, building a small plutonium extraction plant in the future (e.g. in the form of large hot cells) would not be a major technical challenge.

Some commentators refer to a state with enrichment or reprocessing as a *virtual* nuclear-weapon state. The common example is Japan, sometimes described as being "just a screwdriver turn away" from having nuclear weapons. This is simplistic, overlooking the other capabilities required, such as weaponisation and suitable delivery systems[9], as well as Japan's longstanding and strongly held commitment against nuclear weapons. Nonetheless, it illustrates the problem of having enrichment and reprocessing capabilities in national hands. Even a state as firmly committed to non-proliferation as Japan could change its position in the future. Concern this *could* happen is reinforced by comments from some Japanese political figures about the need to maintain fuel cycle capabilities to ensure a nuclear weapon option.[10]

The issue of nuclear latency was very much in the background in negotiations between the U.S. and the ROK for the renewal of their nuclear cooperation agreement, where the ROK was seeking consent to undertake enrichment and reprocessing. While there is no serious suggestion that ROK intentions are anything but peaceful, it cannot be overlooked that enrichment and reprocessing provide proliferation capabilities – and as with Japan, in the ROK some political

9. Some commentators point to Japan's space program as providing ballistic missile capabilities.
10. See e.g. remarks of Japan's defense minister, Satoshi Morimoto, prior to his appointment, reported in the Japan Times, 6 September 2012: http://info.japantimes.co.jp/text/nn20120906b4.html

figures advocate a nuclear weapon option.[11] The renewed agreement, signed in June 2015, refers all future discussions and requests on these matters to a High-Level Bilateral Commission.[12]

Today, in addition to the five recognised nuclear-weapon states[13] and the other four nuclear-armed states[14], there are at least eight other states with demonstrated enrichment capability[15], and four with demonstrated reprocessing capability[16], ten in all (this total reflects that two of these states have both capabilities). Not all of these are perceived as virtual nuclear-armed states, but there is no doubt that the larger the number of states so perceived, the greater the potential destabilising effect on the non-proliferation regime.

As will be discussed, the principal difference between nuclear latency and nuclear hedging, apart from questions of intention, is the time frame. Nuclear latency refers to the possibility of proliferation some years in the future. However, if there are indications that the state is taking steps to reduce this period, e.g. through weaponisation activities or developing nuclear-capable delivery systems, then the state may be approaching – or have crossed – the line between latency and hedging.

B. Nuclear hedging

If nuclear latency might be an unintended consequence of having certain technologies, nuclear hedging refers to a deliberate national strategy of establishing the option of acquiring nuclear weapons within a relatively short time frame. Compared with latency, nuclear hedging has a much shorter time horizon – ranging from several weeks to at most a few years.[17] The shorter time frame reflects the level of preparation – hedging implies that the state not only has fissile material production capacity, but is also undertaking at least some weaponisation activities and developing or acquiring nuclear-capable delivery systems.

If a number of states engaged in hedging, this could result in *virtual* arms races, with the risk of degenerating very quickly into real arms races, break-out from the NPT, and even nuclear war. The problem is how to determine the real intent of a state – how to distinguish between a genuinely peaceful program and a program whose purpose is to establish a nuclear weapon option, or worse, is part of a planned nuclear weapon break-out?

Some of the indicators which could point to an interest in nuclear weapons were outlined earlier. However, some of these indicators will be difficult to detect – so an apparent absence of indicators is not necessarily reassuring – and even if detected, the purpose could be ambiguous. The only visible indicator that a state is hedging may well be that it is pursuing an enrichment or reprocessing program that has no clear civil justification.

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11. See e.g. speech by Chung Mong-joon to the April 2013 Carnegie International Nuclear Policy Conference, reported in the New York Times: http://www.nytimes.com/2013/04/10/world/asia/in-us-south-korean-makes-case-for-nuclear-arms.html?_r=1&
12. Department of State Fact Sheet June 16, 2015, http://www.state.gov/t/isn/rls/fs/2015/243872.htm
13. U.S., Russia, U.K., France and China.
14. India, Israel, Pakistan and North Korea.
15. Argentina, Australia, Brazil, Germany, Iran, Japan, Netherlands and South Africa.
16. Belgium, Germany, Italy, and Japan.
17. Ariel Levite, *Never Say Never Again*, International Security, Vol. 27, No. 3 (Winter 2002/03), pp. 59-88.

5. THE CHALLENGE FOR THE NPT AND SAFEGUARDS

When the NPT was concluded, it was believed that IAEA safeguards would provide *timely warning* of any misuse of nuclear facilities, giving the international community opportunity to intervene before a proliferator has time to manufacture nuclear weapons. It was also believed proliferation risk would be limited because only the nuclear-weapon states and a small number of advanced industrialised states would have enrichment and reprocessing capabilities.

Recent research has brought to light that during the NPT negotiations U.K. officials warned their U.S. counterparts that *centrifuge enrichment* presented a serious risk to the NPT's objectives.[18] Unfortunately this warning was not heeded, and the language in the draft NPT (Article IV) was not amended. The UK's warning proved prescient, as there has been a gradual spread of proliferation capabilities, particularly centrifuge enrichment technology, accelerated by black market activities, notably involving the Pakistan-based AQ Khan network.

As the U.K. warned almost 50 years ago, centrifuge enrichment technology presents a serious challenge to the safeguards objective of providing timely warning – the relative ease of concealing centrifuge plants and the potential speed of break-out mean that in certain circumstances[19] *adequate warning time cannot be guaranteed*. For example, if at the end of the JCPOA's 15 year limitation period Iran proceeds with a one million SWU plant[20], the time required to produce sufficient HEU for one weapon will be reduced from 12 months under the JCPOA to as little as two days. Even if diversion of enriched uranium from safeguards, or use of a *safeguarded* facility for high enrichment[21], is detected immediately, the time taken for international deliberations could mean that practical intervention is not possible in the necessary time frame.

Similar timeliness issues are raised where stocks of separated plutonium are held. The risks are exacerbated where *low burn-up* plutonium is involved, e.g. with fast breeder reactors or large "research" reactors.[22] There is a real possibility that if a state diverts plutonium and has made the necessary preparations in advance, it could fabricate the plutonium into nuclear weapons before effective international intervention is possible.

It can now be seen that the problem of the spread of enrichment and reprocessing was not well anticipated in the language of the NPT. This makes it all the more important for the international community to focus on how the NPT should be applied in today's circumstances.

One traditional view is that whatever is not specifically prohibited by the NPT is permitted. This view is reflected in the argument by Iran and others that the NPT permits a party to pursue *any*

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18. John Krige, *The Proliferation Risks of Gas Centrifuge Enrichment at the Dawn of the NPT*, The Nonproliferation Review, 19:2, 219-227, http://www.tandfonline.com/doi/abs/10.1080/10736700.2012.690961#.UYswj7VBO4I
19. E.g. a state that has an industrial-scale enrichment facility, or the capability to establish undeclared enrichment facilities for upgrading LEU diverted from safeguards.
20. SWU is *separative work unit*, a unit for measuring enrichment effort. On Iran's plans, see footnote 3.
21. One problem here is that production of HEU is not prohibited – if a state started to do this, vital time could be lost on legalistic arguments.
22. Such as Iran's Arak reactor, now to be re-designed under the JCPOA to minimize risk of misuse.

fuel cycle activity so long as this is under safeguards (Iran conveniently overlooks that it has violated this safeguards condition). This position may have seemed reasonable in the past, when it was assumed safeguards *could* provide timely warning of misuse of nuclear programs, but it is not appropriate today, when it is clear that in certain situations this assumption is no longer valid.

This brings us to the issue of nuclear hedging. Since the purpose of hedging is to be able to make nuclear weapons, it is essential to gain international recognition that nuclear hedging is *not a peaceful purpose* permitted by the NPT. Nuclear hedging is contrary to the NPT's objectives – the existence of hedging programs will undermine the confidence and stability that the NPT is intended to promote.

At one time the draft NPT contained language that was helpful on this point – the Soviet draft of 24 September 1965 included the following:

> Parties to the Treaty not possessing nuclear weapons undertake not to create, manufacture or prepare for the manufacture of nuclear weapons either independently or together with other States, in their own territory or in the territory of other States. (underlining added)

Hedging is clearly *preparing for* the manufacture of nuclear weapons. Regrettably this language did not make it into the final text, but the prohibition on non-nuclear-weapon states "not to manufacture ... nuclear weapons" (Article II) should be interpreted as including not to prepare to manufacture nuclear weapons. To "manufacture" cannot be interpreted so narrowly that there is no violation of Article II until a nuclear weapon is fully assembled – this would undermine the practical value of the NPT. Where a state is pursuing enrichment or reprocessing without a clear civil justification, or beyond the scale of its demonstrated civil requirements, there could be good reason to regard this as a step in the manufacture of nuclear weapons, hence beyond the scope of the NPT even if the activity is being carried out (at least for the time being) under safeguards.

6. CRITERIA FOR ASSESSING THE "PEACEFULNESS" OF NUCLEAR PROGRAMS

Some key indicators for assessing whether the underlying purpose of a nuclear program may be to produce nuclear weapons, or at least to provide a break-out capability (whether as long-term latency or shorter term hedging), are outlined in the following discussion. Criteria could be formulated to reflect indicators such as these. The presence of any one of these indicators could be regarded as a warning that the purpose of a nuclear program is not peaceful. A combination of these indicators would be grounds for serious concern.

(i) The state is developing an enrichment and/or reprocessing program that is not commensurate with the scale of its nuclear power program

Enrichment There are limited opportunities for a state to legitimately import enrichment facilities, as the established technology holders (Urenco, Tenex) are very careful about who they supply, and do so only on a *black box* basis. It is not likely they would provide an enrichment facility where the host state's rationale for the facility was questionable.

If a state seeks to develop its own enrichment technology this will be very expensive, and it will be difficult for the state to obtain the specialised components and materials needed. The main suppliers of enrichment-related equipment and materials are members of the NSG, applying the NSG Guidelines. An alternative source may be the *black market*, but illicit procurement is a strong negative indicator, see (iii) following.

Compared with buying enrichment services on the international market, few national enrichment projects could be justified economically. The general industry view is that an enrichment program will not be economically viable unless supplying at least *20 reactors* – i.e. an enrichment capacity of around 3 million SWU/yr. Few states could make a convincing case for needing a national enrichment program – and even if they could, this does not negate the potential proliferation risk presented by such a program.

Reprocessing Historically, civil reprocessing programs were developed because of technical necessity (to manage spent fuel not suitable for long term storage) or in anticipation of the introduction of fast neutron reactors. Notwithstanding the claims of current reprocessing operators, reprocessing for plutonium recycle using thermal reactors is not economically viable, and the waste management benefits are marginal compared to the future possibility of recycle and transmutation using fast reactors. It is difficult to make a convincing case for a new reprocessing project unless and until fast reactors are established.

(ii) <u>The state is stockpiling materials of strategic significance, in excess of demonstrated civil requirements</u>

Examples would be stockpiling of LEU in the form of UF_6 (uranium hexafluoride) in excess of actual fuel requirements (the concern about LEU is its potential use as feedstock for higher enrichment[23]). Other examples would be producing and stockpiling LEU close to the HEU threshold[24], or producing HEU claimed to be required for future nuclear powered submarines. Another would be stockpiling of separated plutonium in excess of actual fuel needs.

(iii) <u>The state is engaged in illicit procurement of nuclear material, equipment or technology</u>

Considering the costs and the consequences – international suspicion, reputational damage, etc. – legitimate civil nuclear programs are not based on illicit procurement. Illicit procurement is a strong indicator of undeclared nuclear activities.

(iv) <u>The state is establishing facility types, or is engaged in unusual facility operations, that could be of advantage in producing nuclear weapons</u>

The question is whether there is anything unusual about the state's nuclear program or the way it is operated, compared with international practice. For example, large natural-uranium fueled

23. For example, LEU at 5% enrichment represents around 70% of the enrichment level needed for weapons grade HEU, i.e. using LEU, weapons grade can be reached quickly with a relatively small number of centrifuges. An important aspect of the JCPOA is limiting the quantity of LEU held as UF_6 by Iran.
24. LEU at just under 20% enrichment represents 90% of the enrichment level needed for weapons grade HEU. This is another important issue covered by the JCPOA.

research reactors are out of place in a modern civil program – if a state is establishing such a reactor, the question arises whether the purpose may be to optimise plutonium production. A related indicator is the presence of large hot cells, in which plutonium could be separated. Another example is abnormal operation of power reactors (e.g. unscheduled fuel discharges for "technical" reasons), resulting in the state accumulating low burn-up fuel.

(v) The state has safeguards problems and deficiencies

Serious safeguards violations, systematic violations, and lack of cooperation with the IAEA are obvious warning signs about whether a nuclear program is really peaceful.

An important criterion, applied by the NSG for sensitive nuclear exports, is whether the state has concluded an *additional protocol* with the IAEA. The IAEA has emphasized that in the absence of an additional protocol it is unable to assure that a state has no undeclared nuclear activities. Even if the additional protocol is not considered mandatory[25], there is no convincing reason why a state in good non-proliferation standing, with nothing to hide, would refuse to accept this, the most effective form of safeguards.[26]

Other indicators, some of which were discussed earlier, include:

(vi) apparent weaponisation activities;

(vii) development of nuclear-capable delivery systems;

(viii) location in a *region of tension*, or other strategic circumstances that could provide a motivation for pursuing nuclear weapons;

(ix) involvement of elements of the military in the operation of a "civil" program.

7. HOW CRITERIA MIGHT BE APPLIED

If states or international bodies (e.g. the Security Council) apply criteria such as those discussed here, and conclude that the purpose of a particular state's nuclear program is, or could be, nuclear weapons development, what could be done?

Current international arrangements are largely *reactive*, the main example being where a treaty violation, in particular non-compliance with a safeguards agreement, is involved. In this case the Security Council can take action, as it has done with Iran and the DPRK.

Instead of reacting to a problem once it has arisen – when it may already be too late for effective intervention – it is preferable to be proactive, to take a *preventative* approach. At present the only established mechanism for this is in the rather limited area of export controls, where

25. See John Carlson, *Is the Additional Protocol 'Optional'?*, Trust and Verify, VERTIC, January-March 2011, Issue no. 132, pages 6-9, http://www.vertic.org/media/assets/TV/TV132.pdf

26. Currently the only NPT non-nuclear-weapon states with nuclear programs that have refused the additional protocol are Argentina, Brazil, Egypt, Syria and Venezuela. Iran had an AP in force provisionally but "suspended" it – in the JCPOA Iran has committed to reinstate it. Algeria had an AP approved by the IAEA Board several years ago but has not yet signed it.

suppliers can decide to deny particular nuclear or dual-use transfers. For example, the NSG Guidelines contain special controls on sensitive exports[27] which take into account some of the factors discussed above. Export denials, however, have inherent limitations – they can apply only to the particular items being sought and not to other parts of a state's nuclear program which may be of equal or greater concern, and they have little effect against a program that is not dependent on legitimate nuclear transfers.[28]

The current non-proliferation regime does not deal adequately with the issue of national activities involving proliferation-sensitive nuclear technologies. Today a significant number of states have the capability to produce fissile material, and if nothing changes this number will increase. Iran's behaviour has highlighted the dangers inherent in national enrichment and/or reprocessing programs. If a state decides to apply these technologies for military use, IAEA safeguards may not be able to provide adequate warning.

An international approval process?

It may be necessary for the Security Council to consider some process for determining the acceptability, or otherwise, of national programs in proliferation sensitive nuclear areas such as enrichment and reprocessing. The Security Council could determine in advance, through the application of appropriate criteria, whether a program presented an unacceptable threat, or potential threat, to international peace and security, and could direct that such programs be ended.

One problem is that a state's circumstances can change over time. A state that gains approval to proceed with an enrichment or reprocessing program may fail the criteria some years later, e.g. because its security environment has changed significantly, after the program has been running for many years. The state might even be found to have started weaponisation activities. At that stage however it will be very difficult to compel the state to close its enrichment/reprocessing program, and it may well be too late to prevent the misuse of this program.

The current Iranian situation has shown the practical difficulties in enforcing international decisions. If the above criteria were in place now, Iran would fail every one. Iran continued its nuclear program in defiance of Security Council resolutions for nine years, and the current negotiated outcome was possible only on the basis that Iran will continue its enrichment program, albeit at a reduced scale for 15 years. Whether this will lead to a more lasting outcome remains to be seen.

8. AN ALTERNATIVE TO NATIONAL PROLIFERATION-SENSITIVE PROGRAMS

The pursuit of national enrichment and reprocessing programs highlights the latency/hedging dilemma. While every state wants energy security – to which nuclear energy could make an

27. INFCIRC/254/Rev.11/Part 1, paragraphs 6 and 7, http://www.nuclearsuppliersgroup.org/Leng/PDF/infcirc254r11p1.pdf

28. Clandestine nuclear activities are often based on illicit procurement, but this is largely beyond the purview of export approval processes.

important contribution – this does not necessitate every state, or even many states, having national programs in proliferation-sensitive technologies. Paradoxically, having such programs could be counterproductive to a state's broader security interests, either directly, due to the threat perceptions and reactions of other states, or more generally through a weakening of the non-proliferation regime. A large part of addressing the latency/hedging problem will be to help states to understand this national security paradox – and to see that their national interests are best served by multilateral approaches.

The only sure way to address the issues of nuclear latency and hedging is to reach international acceptance that proliferation-sensitive stages of the fuel cycle should be under multilateral rather than national control. A new international framework for the nuclear fuel cycle is needed, which emphasises international cooperation in place of national fuel cycle programs. Key elements in the new framework should include *multilateral fuel cycle centres*, fuel leasing, international fuel supply guarantees, international fuel banks, and so on. The IAEA would have a key role in ensuring availability of nuclear fuel, as foreseen when the Agency was established.[29]

9. CONCLUSION

Development of criteria for assessing whether nuclear programs are really for peaceful purposes will help to guide governments and industry, and contribute to establishing international norms of behaviour, including an interpretation of the NPT that appropriately reflects the international interest. A criteria approach may even become the basis for an international approval process for proliferation-sensitive stages of the fuel cycle. Ultimately, however, avoiding latency and hedging will require international support for multilateral rather than national approaches to the fuel cycle.

29. Atoms for Peace speech, https://www.iaea.org/about/history/atoms-for-peace-speech, and IAEA Statute, Article IX.