Should And Can the FMCT Be Effectively Verified?

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A universal fissile material cutoff treaty (FMCT) will be a key building block in nuclear disarmament, nonproliferation, and the prevention of nuclear terrorism. Negotiation of an effectively verifiable FMCT has been pursued for over a decade. At the 2000 Non-Proliferation Treaty (NPT) Review Conference, 13 practical steps for the systematic and progressive implementation of Article VI of the NPT were agreed upon by all States Parties.

One important step emphasized "the necessity of negotiations in the Conference on Disarmament on a non-discriminatory, multilateral and internationally and effectively verifiable treaty banning the production of fissile material for nuclear weapons or other nuclear explosive devices in accordance with the statement of the Special Coordinator in 1995 and the mandate contained therein, taking into consideration both nuclear disarmament and nuclear non-proliferation objectives. The Conference on Disarmament is urged to agree on a programme of work which includes the immediate commencement of negotiations on such a treaty with a view to their conclusion within five years."

However, negotiations on the FMCT have been stalled due to competing negotiating priorities at the Conference on Disarmament in Geneva. The Bush Administration announced in July 2004 that although it supported a cutoff treaty and was willing to resume negotiations, it would no longer support such a treaty if it contained verification provisions. In a *White Paper* issued May 18, 2006, the U.S. argued that "effective verification" of an FMCT cannot be achieved. "The United States has concluded that, even with extensive verification mechanisms and provisions – so extensive that they could compromise the core national security interests of key signatories, and so costly that many countries would be hesitant to implement them – we still would not have high confidence in our ability to monitor compliance with an FMCT."[1] The new US position insisting on an unverified FMCT runs counter to an effort at the Conference on Disarmament to conclude an effectively verifiable FMCT. It is necessary to examine whether the U.S. new position makes sense.

Why Should the FMCT Need an International Verification Regime?

A primary goal of an FMCT will be to attain the signatures of the five NPT nuclear weapon states and three non-NPT countries – India, Pakistan, and Israel (hereafter referred to as eight target states). Ending North Korean production of fissile material would depend on the negotiation of North Korean denuclearization. While all five NPT nuclear weapon states have stopped production of nuclear materials for weapons, India, Pakistan, and Israel are believed still to be producing fissile material for weapons use. Thus, one focus of any useful FMCT must be the participation of the three non-NPT countries.

Without FMCT verification provisions and an international verification mechanism, can the international community have confidence that the target states indeed have ended the production of fissile materials for weapons? While the new US position would not support an FMCT with *international* verification provisions, it wants to verify an FMCT by "national means and methods." This new verification approach of *national* means and methods,[2] which would replace the old term "national technical means" (NTM) in the current US Administration's approach, would allow nations to apply information not only from the NTM, but also information obtained from commercial satellite imaging and other open sources. One question is whether this new verification approach alone can provide confidence in treaty compliance in the absence of an on-site verification mechanism.

To examine this question, I will focus on the three non-NPT countries. Under an FMCT, international society would want to assure that all known major nuclear facilities in the three non-NPT countries (as listed in *Table 1* and *2*) would cease production of fissile material for weapons purposes. For example, military reprocessing facilities used in weapons programs in Israel, Pakistan, and India would be expected to be closed or used for some purpose other than plutonium production. The most effective measures to demonstrate their shutdown status are site environmental monitoring and on-site visits. In practice, on-site inspection has played an essential and effective role in detecting undeclared nuclear facilities and activities, as already shown in the case of North Korea. Satellite imaging would have little role in monitoring these smaller reprocessing facilities, although it could play a complementary role in monitoring the shutdown status of large reprocessing plants, such as those in the US or Russia. Moreover, Pakistan's centrifuge enrichment

Country	Facilities	Status	Note
U.S.	Reprocessing plants (F & H reprocessing areas) at Savannah River Site	Military/S?	Expected to be closed under an FMCT.
	Reprocessing plants at Idaho National Engineering Lab and Hanford Reservation	Military/S	All those military reprocessing plants would be closed. Pilot facilities planned for civilian applications.
Russia	TR-1 reprocessing at Ozersk	Civilian/OP	Could be in operation after an FMCT.
	TR-2 reprocessing at Zheleznogorsk	Civilian/Deferred	
	2 reprocessing plants at Seversk and Zheleznogorsk	Military/OP	Reprocessing spent fuel from 3 production reactors for heating. To be shutdown.
U.K.	The reprocessing plant at Dounreay and B204 at Sellafield	Military/S	.
	B205 reprocessing plant & THORP at Sellafield	Civilian/OP	EURATOM safeguards. Planned to be shutdown in next several years.
France	UP1 reprocessing plant at Marcoule	Military/S	
	UP-2 & UP-3 reprocessing plants at La Hague	Civilian/OP	EURATOM safeguards.
China	2 reprocessing plants at Jiuquan & Guangyuan nuclear complex	Military/S	
	A pilot reprocessing plant at Gausu	Civilian/OP	Began reception of spent fuel from power reactors in 2004. Planned to build a commercial plant around 2020.
India	Trombay reprocessing plant	Military/OP	Expected to be closed after FMCT.
	Reprocessing plants at Tarapur & Kalpakkam	Dual?/OP	Tarapur reprocessing safeguarded when reprocessing IAEA safeguarded spent fuel.
Pakistan	Nilore reprocessing plant	Military/OP	Expected to be closed after FMCT.
Israel	Dimona reprocessing plant	Military/OP	Expected to be closed after FMCT.

Table 1: Major reprocessing facilities affected by an FMCT[3] OP = operating facilities; S = shutdown or standby facilities

Country	Facilities	Status	Note
U.S.	2 GDPs at K-25 & Portsmouth	Military/S	
	GDP at Paducah	Civilian/OP	Expected to be replaced by two planned CEPs (IAEA).
	2 CEPs at Ohio and NM	Civilian/Planned	
Russia	4 CEPs at Angarsk; Seversk, Krasnoyarsk and Sverdlovsk-44	Civilian/OP	Expected to be in operation after an FMCT.
U.K.	GDP at Capenhurst	Military/S	
	CEP at Capenhurst	Civilian/OP	IAEA.
France	GDP at Pierrelatte	Military/S	
	GDP at Georges Besse	Civilian/OP	EURATOM. To be replaced by the being-built CEP at the site (IAEA).
	CEP at Georges Besse II	Civilian/Planned	
China	2 GDPs at Lanzhou and Heping	Military/S	After ending HEU production, both produced LEU for civilian. Lanzhou GDP decommissioned in 1999.
	2 CEPs at Hanzhong and Lanzhou	Civilian/OP	Both in operational; Hanzhong under IAEA.
India	Rattehalli CEP	Military/OP	After FMCT, could it continue to operate for naval fuel?
Pakistan	Kahuta CEP	Military/OP	Expected to be closed after FMCT.

Table 2: Major enrichment facilities affected by an FMCT[4]

plant (CEP) at Kahuta would be expected to be shut down after an FMCT. There would also be a need to monitor the Indian CEP at Rattehalli. The most effective measures to monitor these smaller-scale CEPs (whether shutdown or operating for non-weapon purposes) are on-site inspections. While satellite imaging could play an important role in monitoring the shutdown status of the gaseous-diffusion plants (GDPs) in the five NPT nuclear weapon states, these CEPs will have much less obviously observable characteristics than a GDP has for satellite imagery.

In addition, while satellite imagery would be useful for detecting undeclared nuclear facilities and confirming information acquired from other sources, it is not sufficient for a final determination concerning activities at the facilities. On-site inspection is necessary to resolve any disputes. Finally, if those facilities that were used for nuclear weapons programs continue operating for civilian purposes, satellite imagery would be less useful, because it would be difficult to distinguish between different operating modes (whether for weapons or non-weapons production) of operating facilities. Monitoring these declared operating nuclear facilities would require many on-site inspections, as is the case in implementing safeguards of the International Atomic Energy Agency (IAEA).

Thus, an international verification regime (especially including on-site verifications) would be essential to building confidence in the effectiveness of an FMCT. Moreover, without an international verification regime, some nations would be concerned about abuse of "national means and methods." For example, some nations may be concerned about the equality of national means. They may be concerned that one nation could use shutter-control policies to limit the delivery of commercial satellite images. Related to this is the question of whether a country will allow its commercial imaging firms to deliver satellite images to a rival during a crisis or war. There also is a potential concern that a nation could enter into an exclusive arrangement with the operator of a commercial satellite to buy all images of sensitive sites and thus to deny those images to other organizations. Consequently, it can be expected that there would be countless compliance disputes in the absence of a negotiated arrangement to resolve them.

Can the FMCT Be Effectively Verified?

The verification objective of an FMCT – to ensure that no fissile material is being produced for weapons – is similar to IAEA safeguards for the NPT non-nuclear-weapon states. Thus FMCT verification provisions can be developed based on an IAEA approach that already has accumulated extensive experience in over 40 years of safeguarding nuclear materials and activities. Based on the IAEA safeguards experience, experts have proposed many verification approaches ranging from focused to comprehensive verification schemes. Focused verification would concentrate only on sensitive fissile material production facilities, i.e., reprocessing and enrichment facilities, and on fissile materials produced after an FMCT enters into force, along with the facilities where these materials are present. A wide-scope approach would cover a variety of additional less sensitive civilian facilities, such as fuel fabrication plants and civilian power reactors. It is believed that a focused approach is technically adequate and cost-effective for the FMCT.[5]

After the FMCT enters into force, its verification would focus, in the first instance, on declared former military fissile material production facilities (e.g. uranium-enrichment and reprocessing plants). Many of these production facilities would be shut down (as shown in *Table 1* and *2*). To provide assurance that no operations are carried out in these closed plants, verification activities will include on-site inspections, the use of seals, surveillance or monitors on critical plant equipment, environmental sampling, and remote sensing.[6] As examples, *Table 3* and 4 show some measures that could be applied to verify the shutdown status of a reprocessing plant or a GDP.

Figure 1 shows a Landsat-5 thermal infrared image of the Portsmouth GDP taken March 12, 1994. The hot roofs of the process buildings X-333, X-330, and X-326 are clearly visible. It can be expected that if GDPs are operating, the thermal signatures (e.g. warm cooling tower vapor plumes and the hot roofs of the process building) would be detectable using the thermal infrared images of a commercial satellite.[7] In short, it should be easy to monitor the status of these closed facilities. Some would continue operating for non-weapons purposes. The verification measures necessary for these declared operating facilities would be primarily IAEA-type safeguards.

While the detection of undeclared nuclear facilities would be a challenge, a number of new measures being applied or developed for strengthening IAEA safeguards would make a clandestine nuclear program more difficult. These measures for FMCT verification would include: satellite imagery; information collection and analysis; on-site visits; and environmental sampling as envisioned by the Additional Protocol.[8]

For example, the key fissile material production facilities would have some visible infrastructure signatures for high-resolution satellite imagery (see *Table 5*).[9] In the absence of elaborate concealment measures, all these characteristic visible features would be detected and identified using high-resolution satellite images. In addition, construction activities for all these types of nuclear facilities

Off-site verification	On-site verification
Off-site sampling, for example ▪ Kr-85	Environmental sampling, e.g. ▪ glove box ▪ High-level waste tanks
Satellite remote sensing such as ▪ VNIR: activity level	Visual observation: e.g. ▪ no activity at the railroad cask portal, etc. continuous surveillance monitor and tamper-proof seal, e.g. ▪ outside the canyon building: monitoring the waste stream, etc.

Table 3: Verifying the shutdown status of a reprocessing plant

could be detected by satellite imaging. However, smaller-scale technologies such as gas centrifuge facilities - which could be a preferred approach for future proliferants - will have much less obviously observable characteristics. The identification of a CEP has to rely heavily on other collateral information. Once the satellite imagery detects the undeclared facilities and activities, it could provide the targets for on-site inspections. It could trigger a special inspection with on-site sampling and visual observation.

More importantly, more intrusive measures including complementary access and environmental sampling, as provided for in the Additional Protocol, should be applied to detect and identify undeclared facilities and activities. Moreover, non-governmental organizations, individuals, and government intelligence agencies could also uncover a secret nuclear program, as shown in the unveiling of Israel's Dimona complex. Furthermore,

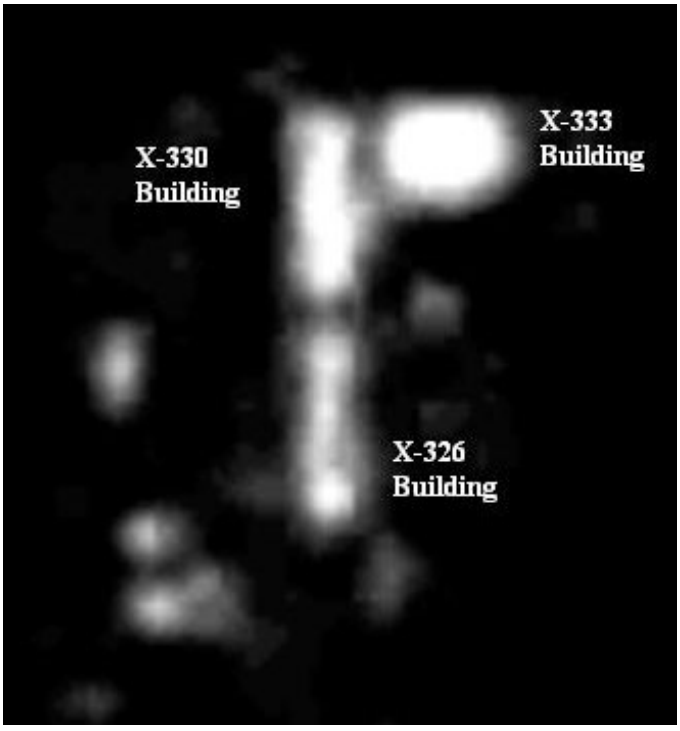

Figure 1: Landsat-5 thermal infraret picture of Portsmouth gaseous-diffusion plant taken March 12, 1994

Off-site verification	On-site verification
Satellite remote sensing: e.g. ▪ VNIR: tower plumes ▪ thermal infrared picture: the hot roof	Site visual observation, e.g.: ▪ outside the cascade building: no plume from the cooling towers no treatment of cooling water, etc. ▪ inside the building: not hot, not noisy Continuous surveillance monitor and tamper-proof seal: e.g.: ▪ seal the high-voltage disconnect switches ▪ seal the valves on the supply and return headers of the Recirculating Cooling Water system ▪ seal the inlet and outlet block valves for the cascade piping ▪ put vibration and or/temperature sensors on the process equipment

Table 4: Verifying the shutdown status of a gaseous diffusion plant

the verification provision itself would play a deterrent role. From the beginning, FMCT verification should be designed to detect and deter noncompliance.

It should be noted that even the detection of a small-scale CEP is a challenge using IAEA safeguards, and such a facility might be small enough to evade FMCT verification. Indeed, a smaller CEP could be easily hidden. And such a small covert CEP (say producing enough HEU for a few bombs per year) would have great strategic significance for a non-nuclear-weapon state, as its status would be changed to that of a nuclear-weapon state. However, such a small, covert CEP could not have great strategic significance for the eight target nuclear states, which already possess significant nuclear stockpiles. Thus, the net risk to world security from the possibility of covert plants in the eight target states is far less than the net gain for world security from verified shut-down of the known production facilities in those states.

Could FMCT Verification Compromise the Core Security Interests of Key Signatories?

Another major question is whether an effective FMCT verification regime could be established while protecting national security secrets. For example, to monitor the shutdown status of a reprocessing plant, one effective verification means would be site environmental sampling. Some target states may worry that on-site sampling analy-

Nuclear facilities	Observable characteristic features
Reactors	Cooling towers or a natural water body (with intake and discharge port); a high narrow stack (or its shadow); a reactor building; security perimeter; railroads, roads; an isolated site, etc.
Reprocessing plants	A very high stack (or its shadow); a long "canyon-like" building (or with vent); some holding ponds or reservoirs for waste or sludge; security perimeter; railroads, roads; an isolated site, etc.
Gaseous-diffusion plants	Large-area (roof) process buildings (the roof of most buildings have ventilation shafts); cooling towers or a nearby river or lakes; a nearby fossil fuel power plant; large electric switchyard (substation); waste management and disposal facilities; security perimeter; railroads, roads; an isolated site, etc.

Table 5: Infrastructure features of dedicated nuclear material production facilities that might be observable from high resolution satellite imagery

sis could disclose sensitive information about their past plutonium production activities, such as the power level at which production reactors had operated and how much plutonium they had produced, data that will probably not have to be declared under an FMCT. Thus, it is necessary to consider whether sampling activities also could reveal the quantity of plutonium produced prior to the FMCT. We have found, however, that sampling analysis at reprocessing plants need not reveal sensitive information relating to past plutonium production at former military plutonium production facilities.[10]

The issues of collocated facilities could be a major challenge to FMCT verification. For example, under an FMCT, the eight target states legitimately would retain some sensitive nuclear processing facilities and activities (e.g. for nuclear weapon assembly/disassembly and weapons material recycling) and nuclear materials (from pre-stocks), which could be co-located with declared or suspected facilities (such as reprocessing and enrichment plants) requiring verification. Thus, some nuclear states could worry about potential loss of sensitive information at those defense-related nuclear processing sites. For such cases, a managed access approach, as in the Chemical Weapons Convention, will be vital to FMCT verification. For most managed access situations, simple procedures are sufficient. Consequently, it is believed that an effective FMCT verification regime should be able to be established while protecting national security secrets. In fact, a U.S. State Department official suggested, in presenting an earlier U.S. government position on FMCT verification at the 1999 Carnegie International Non-Proliferation Conference, "We think that a strong regime of routine monitoring of all [fissile] production facilities and all newly produced material and a regime for nonroutine or so-called challenge inspections would give us enough building blocks to build an effective verification regime."[11]

Finally, is FMCT verification too expensive? As an example, we consider the case of a focused approach, which would be most likely to be acceptable to the target nuclear states. It is estimated that implementing this focused approach in the eight target states would cost about US$ 80-130 million annually (in 2004 dollars).[12] Compared to its security benefits, however, such a cost would be modest. An effective FMCT would make an important contribution to nuclear disarmament, the nonproliferation regime, and the prevention of nuclear terrorism. However, a credible verification regime would be vital to an effective FMCT.

In conclusion, an effective and meaningful FMCT must have a credible verification regime. It should be technically feasible to establish an effectively verifiable FMCT at a reasonable cost, while protecting national security secrets.

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