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Multilateralism as a Dual-Use Technique: Encouraging Nuclear Energy and Avoiding Proliferation

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Recommendations

- Multilateralism should be welcomed in principle both as a means to promote nuclear energy and for its nonproliferation values.
- In practice, it should be pursued ad hoc making use of existing facilities, where they exist, as a nucleus; regional cooperation, where politically feasible, makes particular sense.
- As a contribution to meeting their obligations under the Nuclear Non-Proliferation Treaty (NPT), the nuclear states should make special efforts, including financial ones, to assist in the establishment of the first few multilateral organizations.
- Multilateral facilities should normally be sited in accordance with Article IV of the NPT in "the developing areas of the world."
- Since a multilateral operation is by its nature big, complex, and expensive, it should be undertaken only if sufficient political will has been committed and confirmed by a treaty covering the main points.
- No one participant should be able to override the others.
- All participants should be members of the NPT or should at a minimum have accepted the main NPT obligations.
- The operations should be run on commercial lines.
- The International Atomic Energy Agency (IAEA) should be consulted from the outset.
- Technical measures to prevent expropriation by the host country should be investigated and applied as appropriate.

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For governmental decision makers in any country, national problems involving high capital costs are potential candidates for multilateral organization and funding. This is especially true if cost-effectiveness, as for example with electricity, is important to electorates. Spreading the costs, employing top-quality technology, assuring security of supply, and proving their prowess in prestigious projects appeals to all governments. Multilateralism may be the only way to achieve these objectives for countries whose needs or resources are below the level at which a self-sufficient national program is cost-effective or even possible. For all countries, it offers a gateway to security of fuel supply without political strings.

As one example, from the dawn of the nuclear age, nuclear energy has been well-suited for multilateralism, both economically and politically. In the political field, this affinity can be seen in the Baruch Plan, Atoms for Peace, the International Atomic Energy Agency, and the Nuclear Suppliers Group. In the industrial field, it is seen in Urenco (a consortium of the British, German, and Dutch governments) and the French-dominated European Gaseous Diffusion Uranium Enrichment Consortium (Eurodif). Urenco and Eurodif show that multilateralism can be attractive even to advanced wealthy countries. For smaller, less advanced, or poorer countries the case for multilateralism is still more compelling. In addition, by obviating the need for nationally owned-and-operated facilities, multilateralism makes an important contribution to nonproliferation.

The nub of the case is cost-efficiency, but until the recent surge in expectations of the use of nuclear power, much of the argument has been cast in political and nonproliferation terms. The case for multilateralism rested on twin pillars: assuring security of supply despite hostile political interventions and reducing if not eliminating the need for enrichment and reprocessing plants in countries that do not already possess them.

Recognizing these issues and their tensions, in June 2004 IAEA Director General Mohamed ElBaradei tasked an expert group, chaired by Dr. Bruno Pellaud, to deal with the concern "that wide dissemination of the most proliferation sensitive parts of the nuclear fuel cycle could be the 'Achilles' heel' of the nuclear non-proliferation regime." Subsequently, this "Pellaud group" issued a February 2005 report focused on assurances of supply and services not involving ownership of facilities. (This is presumably why the report refers consistently to *Multilateral* Nuclear Arrangements [MNA] rather than to *International* ones.) It also covers, much less comprehensively, two other types of multinational or multilateral arrangements: the conversion of existing national facilities to multinational control and the construction of new facilities, multinational from the first.

The market mechanisms that the Pellaud report commends and proposes to strengthen have worked well. If everyone is content with this system, there is no reason to change it. However, some countries worry that it is or may become unfair and unreliable. If the manufacturing and sale of nuclear materials and services is profitable, why should the business be reserved to a few countries? If it is not, what explains their keenness to maintain their cartel-like monopoly? Underlying the rationale for these and similar questions is the fact that the five permanent members of the UN Security Council are also the only five countries officially classified as nuclear weapon states (NWSs) and that among them they control the bulk of the legitimate market in nuclear sales. The other countries with significant share—Germany, Canada, and Japan—are closely associated with the three Western permanent members. The "big boys" seem to have the nuclear power market sewn up.

The present level of resentment against the United States is unprecedented. Much of this is due to the adventure in Iraq, and American protection of nuclear-armed Israel does not help. Some of it is closely connected with the issue of security of supply. The United States has shown itself ready—often eager—to impose sanctions on regimes it does not like. However justified these sanctions may be to an objective observer, on nonproliferation grounds they still constitute a threat to security of supply, and all the more so in light of the Bush doctrine of anticipatory preemption. If the United States looks unreliable, Russia seems even more so. It has already cut off oil and gas supplies to some of its neighbors, thereby closing the supply lines to more distant customers in Europe. Russian rhetoric leaves no doubt that the supply of energy will be used as a political weapon to achieve national ends.

Political resentments and uncertainties are largely to blame for what appears to be a growing unwillingness to depend exclusively on the existing market for nuclear supplies and services. If the Great Powers would amend their behavior in ways acceptable to potential customers (an issue to which we return below), dependence on existing market mechanisms would become more viable. But this does not necessarily mean that the old monopolies can be safely maintained. So much damage has already been done that it will be hard to restore confidence. Moreover, if there is a renaissance in nuclear energy, confidence will be required on a larger scale and by more people than ever before. To insist that the present market arrangement is the only answer looks politically unacceptable and economically risky.

We do not know whether the world is on the cusp of a nuclear renaissance or, if so, how far and fast that might proceed. Yet on the basis of current trends, it seems reasonable to suppose that several countries will want to include some "exposure" (as the stock brokering fraternity says) to nuclear in their energy portfolios. They will not want to be left behind if it turns out that nuclear energy is cost-effective, reliable, and safe—all of which are possible judgments—and their scientists and engineers may well feel challenged to compete globally. On balance, environmental considerations also push in this direction. However, the long lead-times for nuclear construction and the high capital costs mitigate against a sudden dramatic surge. Besides, a significant proportion of existing facilities will reach the end of their projected life within the next two decades.

For our current purposes, we therefore suppose a considerable increase in the number of new countries that will be weighing the pros and cons of nuclear power, and we assume that all countries already possessing nuclear reactors will consider whether or not to expand. Probably this will lead in the next two decades to an increase in the number of countries using nuclear power, but not to an enormous increase in the number of reactors.

If these suppositions prove to be approximately correct, it seems likely that there will be a demand for all three types of MNA considered in the Pellaud Report. That report, as we have said, has covered in considerable detail possible improvements in market mechanisms, and therefore we do not dwell on that further. Instead, our object is to work out in comparable detail what shared ownership might look like.

Obviously, every case will have its own special circumstances. Some cases may be regional, cultural, or political; others will be commercial and financial; still others will have to do with which part or parts of the fuel cycle are concerned especially (but not exclusively) with enrichment, reprocessing, or long-term storage and whether any of the prospective partners already possess such facilities. With that said, and allowing for the need to negotiate each MNA separately, we believe that the generalized model we sketch below will give useful guidance irrespective of which part of the fuel cycle is at issue; this will do as well for the multilateralization of existing facilities (Type 2 in the Pellaud Report) as for building new multilateral facilities from scratch (Type 3).

Political Will

We have already shown that multilateral projects in principle have important advantages, especially for countries with medium or small nuclear power projects and for countries that lack abundant sources of capital or technology. Against that must be weighed the difficulties inherent in any international project: How much control does each participant have? Who has the final say? Are their professional standards compatible? How are disputes to be resolved? These are all problems that have been and can be satisfactorily managed, but an international partnership on such an ambitious project is like marriage: it is not to be entered into lightly or unadvisedly. Unless there is a political will strong enough to overcome problems, it is probably better not to begin.

Exclusive Commitment

Political will is on trial from the beginning since it will be essential (with some exceptions) for participants to promise not to set up new national plants in parallel with the MNA plants. For example, if the MNA is to be a shared enrichment facility, the participants should undertake not to establish enrichment facilities on their soil or under their national control. This is partly to prevent the theft of technology, partly to avoid conflict of interest, and partly for nonproliferation reasons. It applies particularly to the host country but as far as practicable should apply to all participants. It would not, however, be practicable to apply it retrospectively to participants who already own national enrichment facilities—unless they were contributing these to the MNA—nor would it bar a country from investing in more than one MNA.

Form of Agreement

Political will is also a factor in the question of what sort of agreement to negotiate. A treaty is best because, if achievable, it does most to secure political commitment and it is a natural type of agreement between governments. The form of a treaty may not be indispensable, but comprehensiveness and clarity are. It will be simplest if the partners are all governments, but we do not want to rule out the possibility of participation, whether from the outset or later, by one or more commercial companies. However, we advise against allowing commercial participation unless the responsible government or governments, both legally and as a political matter for the company concerned, are as fully and legally committed as the directly participating governments. The treaty must provide machinery for the settlement of disputes.

Decision Making

In the same line of thought, the treaty (or whatever other form of agreement is adopted) must exclude the possibility that any one participant could exercise a degree of control that could override the wishes of the others. This raises the delicate issue of the position of the host government. Inevitably this government will have advantages and burdens that are somewhat different from those of the other participants. For example, although the host government will operate like the others on a commercial basis, it will probably on that basis have some advantage in terms of costs and probably also in terms of employment and the import of capital. Against this, it will have to agree that the installations of the partnership have the extraterritorial benefits of an embassy and that the foreigners employed by the partnership have rights modeled on customary diplomatic rights.

It will be prudent to recognize the special position of the host government by providing in the treaty that it has the right to require the partnership to leave its territory provided (1) that an appropriate amount of time is allowed, say three years; (2) that the host government pays the costs thus incurred; (3) that an explanation is formally made public.

Such action by the host government will not automatically cause the partnership to terminate. On the contrary, it should give the other participants the right to buy out the host country and continue without it.

Similarly, it should be stipulated that no participant may sell or assign its participation without the consent of all the others. New participants may be inducted by unanimous invitation.

Membership and the Nuclear Non-Proliferation Treaty

Given what is said above about government responsibility, it will be logical and simplest to provide that all of the participating governments must be signatories of the NPT in good standing. However, we can imagine circumstances in which both non-NPT and NPT signatories see advantage in a deal allowing the former to become participants. The quid pro quo would be a formal agreement whereby the nonmembers, while not signing the NPT itself, committed themselves to observing the provisions of its first six articles.

The Organizational Structure of an MNA

It would be a mistake to insist that all MNA have identical structures. After all, experience may suggest improvements. Yet a worked-out model structure will help to reveal the strengths and problems of the MNA concept. We suggest the following.

Allowing for the foregoing points (e.g., no participant can dominate the others), a commercial model seems best. The participants would be shareholders in a formal organization set up by treaty. Both the contributions of capital and the distribution of profits would be in proportion to their shares. Each participant with at least X% (perhaps 5%) of the shares would be entitled to appoint at least one director of the organization. The directors on behalf of their governments would be responsible for establishing and overseeing policy, for financial control, for discussions with governments, and also for hiring and overseeing a management company that would be responsible for the day-to-day operations of the business. This company may well need to be formed ad hoc for this purpose since it will need to have an international character and a high level of professional expertise. Theoretically, the directors could run the business themselves, but since many people of different nationalities and diverse talents will have to be hired, it is probably better that experienced professional management run the operations while freeing the board of directors from the operational details in order to concentrate on large policy issues and government relations.

The IAEA

The board will need a close relationship with the IAEA, yet the two bodies must remain separate and at arm's length. The IAEA should become (with the consent of the board of governors) the "regulators" for MNA. It is the agency obviously best fitted to monitor operations to ensure that there is no diversion of materials from specified procedures and purposes. (It would make no sense to set up a new agency to do what the IAEA already does well.) Close relations are desirable to ensure that the facilities are designed (for example, in their piping and valves) to facilitate monitoring. At the same time, there will need to be a firm and formal agreement between the MNA and the IAEA to ensure that the latter will be in a position to provide material and services (for example, fuel or storage) to countries in good standing with the NPT who are prevented for political reasons from obtaining materials or services in the normal way.

Commercial Considerations Crucial

The MNA should be run on commercial lines with politics, so far as possible, kept at bay. Thus, the compensation for the management company would be comparable to that of peer enterprises, and the pricing of the product and services would be competitive. MNA would no doubt benefit from drawing the large sums necessary as starting capital from governments or government- backed funds, but they would not be directly subsidized. Management decisions, including investment in research and development, would be grounded in commercial calculations.

If, over the long run, an MNA fails to make a profit, it may have to be wound-up. Provisions for winding-up must be included in the founding treaty.

Buying or Leasing Equipment

If the MNA is Type 2 (i.e., it incorporates existing facilities), the arguments for leasing are strong. If the enterprise was wound-up, the equipment would then return automatically to its owners. The same would hold for equipment brought in to replace the original incorporated equipment. The move from one to the other would be made on commercial grounds, and there would be no problem of factoring in sunk costs. Leasing would probably also be preferable for political reasons. In the case of a Type 3 MNA (one which started from scratch without existing facilities), the board would have choices between whether to own outright or to lease goods and services. Again, commercial considerations would normally outweigh political ones. The land on which the facilities stand should probably be owned by the MNA with a provision that it could not be sold or leased except to the host government.

Personnel

We have determined the international composition of the board of directors above. The management company would also be internationally manned. Expertise would be the first requirement so the numbers from different nationalities would not necessarily be proportionate to shareholding, but all participants would be represented. Moreover, the manning for each shift in the technically sensitive operational areas would always represent at least three different nationalities, and when repairs or adjustments had to be made that would reveal commercial or proliferation secrets, only personnel licensed by the appropriate manufacturers would be allowed to participate. Without this restriction (which would in any case be necessary on nonproliferation grounds) there would be no chance that the MNA could buy or lease the most advanced equipment and techniques. The nonproliferation advantages of international manning are discussed below.

Sites for MNA

Safety must be the prime consideration. In general, earthquake-prone sites are not desirable, but this need not rule out whole countries. For long-term storage, geological stability is crucial. Ease of transport is both a safety and a commercial consideration, but this should not exclude the possibility of upgrading existing infrastructure or even new building if the site is otherwise suitable. Regional considerations and especially the geographical relationships of the countries involved will often point to potentially suitable sites.

Participants are already committed by Article IV, paragraph 2, of the NPT to favor "the developing areas of the world." (That paragraph reads in part: "Parties to the Treaty in a position to do so shall also cooperate in contributing alone or together with other States or international organizations to the further development of the application of nuclear energy for peaceful purposes, especially in the territories of Non-Nuclear Weapon States [NNWSs] Party to the Treaty, with due consideration for the needs of the developing areas of the world.") Subject to safety and some commercial considerations, sites in developing areas in NNWSs ought normally to be picked.

Nonproliferation Considerations

The NPT is the basic international agreement assuring its members (the whole world minus India, Israel, and Pakistan) of equitable access to the peaceful benefits (mainly in power and medicine) of nuclear technologies. Unfortunately, the international regime based on the NPT is beginning to unravel for political reasons. All will suffer if the process continues, but that does not ensure that the political problems will be overcome. Those who can strengthen the regime would be irresponsible not to do so, starting with the five NWSs and especially the United States and Russia. To prepare the ground for a successful outcome at the 2010 Review Conference of the NPT, they need to take urgent steps toward fulfilling their obligation to eliminate their nuclear arsenals.

There is a parallel obligation on the NNWSs to avoid any step that could promote proliferation; this is important because it is the counterpart to their right to technology. MNA, as we have stated above, can play a significant role in preventing proliferation. Multilateral facilities are inherently less open than national ones to the diversion of materials or to threats to "go nuclear" in a military sense. In addition, they can provide a safe setting for the absorption of existing national facilities that may be seen as threatening, for example, the Iranian enrichment facility at Natanz. So it behooves all members of the NPT to support the concept of MNA and to make them in practice as attractive and as effective as possible.

One important step to this end is to enhance the IAEA's capabilities so that it may play the role outlined above both in promoting nuclear energy and in safeguarding the process. Another is that care should be taken with the manning of the management company to make it as professionally competent as possible and also proliferation-resistant. Nothing works better than having trusted people working in close collaboration so that any cheating quickly becomes apparent. (For further discussion see the Annex.) A third important step might be to incorporate technical safeguards into the machinery to protect it against espionage and to destroy or disable it in the unlikely event that the host country used force to expropriate the facilities. (This, too, is discussed in the Annex.)

In conclusion, two general points must be recognized. One is the impossibility of guaranteeing that proliferation can be prevented under all circumstances. This being so, the second point becomes crucial: the most effective way of reducing the risks is to make it "unthinkable" for each government to acquire weapons. This can be achieved by restoring and bolstering the international nonproliferation regime.

Annex

Organizational and Technical Safeguards

Technical safeguards, if appropriate at all, will vary with the type of facility concerned (e.g., conversion plant, reprocessing, long-term storage, etc.). No doubt the same will be true to some extent with organizational safeguards. Accordingly, in a short paper, there is limited usefulness in elaborating on what might be required. For most readers, the treatment above should suffice. However, there may be some who want to delve deeper. For those we reproduce below our thoughts on what might be done in the specific case of a multilateral enrichment facility in Iran with British, Dutch, French, and German participation (hence the use of the term *Western*).

"Technical" Safeguards

It is generally accepted that an economically viable enrichment plant should have a capacity of at least 5 million Separative Work Unit (SWU)-kg/yr. Even if the most advanced centrifuge design is used, thousands of advanced centrifuges will be in-country when the plant reaches its final capacity. During installation, and perhaps at other times, there will be a large number of centrifuges that are not mounted in their permanent positions, and the host country might divert or examine them for reverse-engineering purposes. However, it is possible to mount "so-called" active radio frequency identification (RFID) permanently on the outer casings of each centrifuge that monitors acceleration and motion, both while they await installation and after they have been permanently mounted. Once installed, the rotors would also be protected by the casing's RFID. Until then, the rotors would be kept in their shipping boxes that are protected by seals and their own active RFID.[1]

A common concern with building a multinational enrichment facility using advanced centrifuges in a host country that does not have the same level of technology is the possibility of the facility being "nationalized." However, technical measures can be taken to lengthen the time it would take the host country to get the facility up and running after such nationalization.

We believe that both safe and reliable self-destruct and disabling mechanisms[2] can be built into each and every centrifuge in the joint enrichment facility. Both of these mechanisms can be accomplished without explosive charges or other crude forms of destruction that would pose a risk to workers in the course of their normal activities. The destructive power is inherent in a spinning centrifuge rotor, which has almost the same magnitude of energy per kilogram as a stick of dynamite. In fact, one of the important design problems that had to be worked out early in the development of centrifuges was a way of ensuring that shrapnel from a "crashed" centrifuge did not destroy nearby centrifuges and set off a domino effect of destruction.

The details of both of these mechanisms will depend on the details of the centrifuge on which they are installed. In general, however, all centrifuges share a common design feature: the motor that spins the centrifuge rotor is fastened to the bottom of the stationary outer casing and is "potted" in place.[3] It is just this common design feature that we propose to make use of in both types of mechanisms by placing an encrypted electronic-key circuit inside the motor (see Figure 1 below). If Iran wanted to remove these key circuits, it would have to disassemble the centrifuge, dissolve the epoxy surrounding the motor, remove the key circuit, repot the motor, and reassemble the centrifuge. While this is theoretically possible, Iran would have to develop the procedure—having never seen the insides of the centrifuge before—and then repeat the process thousands of times; once for each centrifuge. This could take a considerable amount of time, time that could be used for responding to Iran's actions. Of course, if a self-destruct command had been issued to the key circuit before the centrifuge stopped spinning, the centrifuge would be completely destroyed.

There are several ways of implementing a disabling mechanism. In one, the encrypted key circuit could require a periodic digital signal just to keep functioning. Thus, for instance, an employee designated by the non-Iranian partners in the joint venture might be required to send a code to each centrifuge once an hour; otherwise, the key circuit would shut down the power going into each centrifuge. (This is not as tedious as it might appear since a central computer could relay the different codes required for each centrifuge.) The enabling code is sent together with a message-authentication code to assure that a forged signal is not being sent. Encrypting such authentication codes is now well known from electronic banking applications.

Alternatively, a designated operator could send a disabling code to each and every centrifuge that would permanently open the power circuit and prevent any centrifuge from receiving the power needed to keep its motor turning. This later method, however, has the disadvantage that it could be foiled by preventing a single command from being sent, perhaps by cutting the signal wires or blocking the employee from performing his duty.

The same electronic-key circuit used to disable the centrifuges could also be used to destroy them. Instead of merely interrupting the incoming power, the circuit could reverse the order of two of the three input power "phases."[4] When that happens, the induction magnet spinning the centrifuge would lose its ability to systematically turn the rotor and would cause it either to crash catastrophically against the outer casing or to destroy the main bearing on which the centrifuge sits. A catastrophic crash would clearly disable the centrifuge but could represent a potential safety hazard to workers inside the cascade hall. (Modern centrifuges are designed to contain any shrapnel or fragments that might be created during a crash, but it still might be dangerous to have 50,000 of them crash all at once. More detailed knowledge about the designs of centrifuges than is publicly available is needed before a definitive answer to the question of worker safety can be given.) It is also possible that this reversing of phases could be done in a way as to ensure that only the rotor's critical bottom bearing is destroyed. This bearing is so critical to the centrifuge's operation, and is so technologically sophisticated, that if destroyed, the centrifuge is rendered permanently inoperable.

No centrifuge manufactured today has had either a self-destruct or a disabling mechanism built into it, and so no matter what solution is found, there will have to be a development program. However, we are confident that both of the mechanisms discussed here can be effectively adapted for existing centrifuge designs and that they will withstand attempts to circumvent them.

The self-destruct mechanism should be effective enough to keep the centrifuges from being used again. However, it would, given enough time, be possible to rehabilitate centrifuges that had been disabled using the mechanism outlined above. We can estimate how long it would take to restore a single centrifuge to operation assuming that no time is taken to develop the techniques necessary to remove the electronic-key circuit—remembering that the host country has not seen the inside of the centrifuge and is planning simply on the basis of fundamental design principles—and that no mistakes are made. Of course, the host country could have a number of teams working in parallel and so could reconstitute a number of centrifuges at the same time. We arbitrarily assume 75 such teams.

We assume each centrifuge will take a day to disassemble and that this is labor-intensive, so each

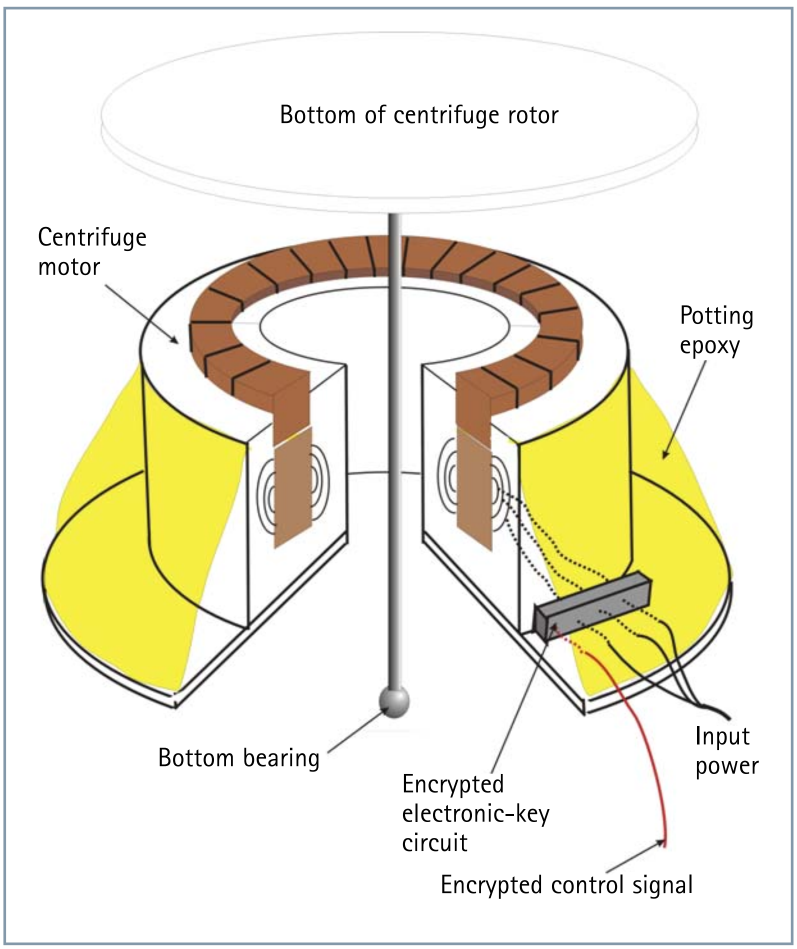

Figure 1. *A centrifuge motor with an encrypted electronic-key circuit embedded in its power train.*

team can only disassemble one centrifuge at a time. The next day is spent dissolving the epoxy in which the motor is potted. This is not labor-intensive, and the team could disassemble another centrifuge at the same time. At this point, the host country could choose to simply replace the motor, either with a reverse-engineered duplicate or an indigenously designed replacement, or it could unwind the motor, remove the circuit, and then rewind the motor.

We believe that the fastest approach would be for the host country to opt for the wind/rewind approach. We therefore estimate that each motor would take a week to unwind and another week to rewind. This is labor-intensive but probably only requires a single team member. Finally, it would take another day to repot the motor and a final day to reassemble the centrifuge. Thus, a two-man team could rehabilitate two centrifuges in 19 days. These time estimates are probably independent of the centrifuge design. While it is possible to speed the rehabilitation of a single centrifuge by working multiple teams around the clock, it would not shorten the time needed to reconstitute a cascade since different teams could be working on different machines in parallel.

If the centrifuges are the new Urenco TC-21 design, which is reported to have approximately 100 SWU-kg/yr enrichment capacity, then 75 such teams could reconstitute a 150-machine cascade in 38 days. Such a cascade could enrich enough weapons-grade uranium for approximately two bombs per year. If Russian centrifuges are used—which are much shorter than Urenco designs—and if they are the same type as sold to China with an enrichment capability of 2.5 SWU-kg/yr, it would take considerably longer to reconstitute enough for a cascade capable of a single bomb's worth of weapons-grade uranium.

Endnotes

[1] It might be a problem to tag all the centrifuges in a large cascade hall with RFID because of the difficulties associated with sending signals through the forest of metal centrifuges. However, there are possible workarounds to this. One possibility that the US national labs are developing is microwave-based RFID that are much less sensitive to any shielding effects such a cascade might represent.

[2] We thank Mr. Julian Whichello for suggesting the disabling mechanism and for very helpful discussions on implementing both the self-destruct and disabling mechanisms.

[3] "Potting" involves embedding the motor, in this case, in a thick matrix of epoxy. While this epoxy can be dissolved, exposing the motor so that it can be modified or repaired takes a considerable amount of time.

[4] In order to have as uniform a power level as possible, centrifuge motors are run with three input electronic phases as opposed to the more widely known single-phase circuits used in most houses. While the single-phase wires in most American homes have one wire held at ground and the other oscillates between minus 120 volts and plus 120 volts, a three-phase system delivers power more equally on three separate wires.

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