Routes to Nuclear Weapons: Aspects of Purchase or Theft

by

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EXECUTIVE SUMMARY

Among the routes to nuclear weapons are purchase, barter, or co-production, and theft. In analyzing the former, nuclear black marketeering has to be differentiated from nuclear gray marketeering, while discussion of theft requires that consideration be paid to possible theft not only of American nuclear weapons but also those of new nuclear-weapon states.

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Nuclear black marketeering would entail the exchange of diverted or stolen fissile materials or nuclear weapons among a variety of conceivable buyers and sellers. Its scope theoretically could range from intermittent transactions in such illicit nuclear commodities to intricate, continuing black market networks.

More specifically, the future level of potential black market activity would be bounded initially by supply availability and, most importantly, by whether or not plutonium emerges as a freely traded legitimate international commodity. Within that constraint, the scope of nuclear black marketeering would be influenced by the interaction of demand and response factors.

In particular, whether or not high demand develops--bringing with it incentives for potential suppliers to attempt to fill that demand--is likely to be determined by conflict-related shifts in perceptions of nuclear weapons' utility, the scope and pace of future proliferation, and such idiosyncratic occurrences as the emergence of new-style terrorist groups seeking nuclear weapons or their critical components. But then the extent to which potential buyers in "high-demand" situations actually attempt to induce or engage in black market transactions would be influenced by their assessment of the risks and costs of doing so. A similar risk-benefit calculus would influence the actions of potential suppliers. For both, the most critical determinant of their risk calculus would be estimates of the likely responses to their activities and the consequences of unsuccessful nuclear black marketeering.

Nevertheless, even with the threat of severe responses perhaps sufficient to deter most buyers and sellers, if plutonium is traded freely in legitimate international commerce, the outcome at the very least is likely to be the emergence of intermittent nuclear black market transactions.

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Of equal, if not greater, importance as an aspect of purchase, barter, or co-production of nuclear weapons or their critical components would be nuclear gray marketeering. This would encompass a

broad spectrum of activities, ranging from covert or officially unacknowledged government-to-government assistance in developing nuclear weapons to covert assistance to aspirant nuclear-weapon states by individual nuclear-industry firms or by unauthorized officials within them and would include the ready availability of nuclear mercenaries.

As with nuclear black marketeering, the emergence of intermittent transactions should be distinguished from growth of a full-blown market. Not only can possible precursors of intermittent gray market transactions already be identified, but what stands out in an assessment of conditions for gray marketeering is the gradual growth of potential supply, the prospect of increasing demand, and the probable steady emergence of strengthened pressures upon potential suppliers to engage in such nuclear activities. All suggest the possible emergence of nuclear gray marketeering by the 1980s.

However, the impetus to gray marketeering provided by the preceding combination of factors is countered partly by structural limits upon plausible buyer and seller combinations and possible difficulties in bringing buyers and sellers together. But, even so, if nuclear gray marketeering is to be kept from taking-off and to be held at the level of intermittent transactions, strong responses to its initial outcroppings will be required.

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The importance of efforts to prevent the emergence and/or growth of nuclear black and gray marketeering becomes clear once their probable consequences are noted. Either or both would increase the scope, accelerate the pace, and adversely change the characteristics of proliferation. And these consequences would, in turn, exacerbate the problems of managing in a proliferated world.

But, particularly for nuclear gray marketeering, policy responses probably would be hindered by the difficulties of detecting it in the "noise" created by growing trade and the migration of trained manpower among many countries. Penetrating that "noise" could require reliance upon human intelligence sources.

As for potential responses to nuclear black and gray marketeering, three approaches warrant further analysis: intelligence-gathering, target-hardening, and politico-military responses. Even if such responses proved unable to prevent some initial black and/or gray market intermittent transactions, they might suffice to prevent their expansion into full-blown market networks.

Much recent attention has focused upon the possible theft of an American nuclear weapon abroad. These weapons have various subsystems to prevent their unauthorized use and are accompanied by assorted protection systems to prevent unauthorized control.

In evaluating the security of such American weapons, the threat of theft and removal should be distinguished from that of control where a storage site would be penetrated successfully and that penetration and possession utilized for any of a variety of purposes but the weapon(s) would not be removed. Extrapolating from past historical experience with small unit surprise attacks, protection against unauthorized penetration probably is significantly more difficult than preventing weapon removal.

Assessment of the future dangers of nuclear-weapon theft also should consider possible theft of weapons from the arsenals of new nuclear-weapon states. This latter risk, due to possibly inadequate Nth country command and control mechanisms, could be especially troublesome should more widespread proliferation occur in the coming decades.

I. INTRODUCTION

During the coming decades, pressures upon various countries to acquire nuclear weapons are likely to mount, while efforts by sub-national groups to gain access to these weapons can be expected.* Table 1 lists alternative possible paths to nuclear-weapon acquisition, two of which are examined by this report: purchase, barter, or co-production, on the one hand, and theft, on the other. In particular, the following report argues that the risks of nuclear black and/or gray marketeering should be taken seriously; it also examines prospects for nuclear-weapon theft and especially how those prospects could worsen if more widespread proliferation occurs.

Table 1

ROUTES TO NUCLEAR WEAPONS

1. DEDICATED FACILITIES
   - A. FOR WEAPONS
   - B. UNDER GUISE OF PNES

2. NUCLEAR-POWER ROUTE
   - A. COVERT DIVERSION
   - B. OVERT VIOLATION OF SAFEGUARDS AND RELATED AGREEMENTS

3. PURCHASE, BARTER, AND CO-PRODUCTION
   - A. "BLACK MARKETEERING"
   - B. "GRAY MARKETEERING"

4. THEFT
   - A. MATERIAL
   - B. WEAPONS

*See Lewis A. Dunn and Herman Kahn, Trends in Nuclear Proliferation, 1975-1995 (Hudson Institute, HI-2336/3-RR, May 15, 1976). Report prepared for the U.S. Arms Control and Disarmament Agency, Parts I and II.

II. PURCHASE, BARTER, OR CO-PRODUCTION OF NUCLEAR WEAPONS OR THEIR CRITICAL COMPONENTS

Under the category of purchase, barter, or co-production of nuclear weapons or their critical components, two types of activity should be distinguished: first, nuclear "black marketeering," entailing illegal exchange of stolen or diverted nuclear weapons or fissile materials; and second, nuclear "gray marketeering," ranging from suspect, though not necessarily illegal, government-to-government nuclear-weapon-related transactions to the buying and selling of the knowledge and services of scientific mercenaries. Each is discussed before turning to an assessment of the possible consequences and detectability of such activities and of potential responses for either preventing their emergence and growth or limiting their disruptive impact.

A. Nuclear Black Marketeering

1. Types of Transactions

According to a standard definition, black marketeering involves "illicit trade in goods in violation of official regulations."* Before discussing conditions for black marketeering, what might be traded and by whom should be categorized briefly.

The "Goods"

On the one hand, most attention has focused upon dealing in either diverted or stolen plutonium. As discussed below, under some conditions

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* Webster's Seventh New Collegiate Dictionary (Springfield, Mass: G.&C. Merriam & Company, 1972), p. 88.

sufficient quantities of separated plutonium might be available globally by the 1980s to constitute a growing potential supply. Alternatively, low-enriched uranium also could become a black market commodity. Once natural uranium has been enriched from 0.7% to 2-4% U-235 content, about 80% of the separative work for boosting low-enriched uranium up to 90% U-235--sufficient for a bomb--has been accomplished. Assuming widespread late 1980s dissemination of new enrichment technologies, such as gas centrifuges and laser isotope separation, and that these technologies prove amenable to covert use, countries might be tempted to establish covert enrichment plants designed to boost upward black-marketed low-enriched uranium. Or, to take the preceding one step further, if these new technologies are accessible to well-financed and technically capable criminal organizations, they might first acquire low-enriched uranium by theft, boost it up, and then market it. If so, such high-enriched uranium also needs to be considered as a potential black market commodity.* Thus, in theory, given certain assumptions about energy choices and technological progress, plutonium, low-enriched uranium, or high-enriched uranium all might be exchanged on a nuclear black market.

On the other hand, as opposed to dealings in diverted or stolen nuclear materials, nuclear black marketeering could entail the exchange of stolen nuclear weapons or fissile materials "mined" from such weapons. Of particular concern here, as discussed more fully below, would be the

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*Another source of high-enriched uranium would be supplies of fuel for HTGRs. Recent cancellations of orders for these reactors in the U.S., however, suggests that the magnitudes involved may be small, particularly if German and Japanese enthusiasm for HTGRs (as heat sources for advanced steel-making facilities) wanes.

theft and then sale of nuclear weapons from new nuclear-weapon states. This is not unlikely because for political and technical reasons such countries may lack adequate command and control procedures for their nuclear forces and stockpiles.*

Buyers and Sellers

Prospective buyers could include countries; sub-national terrorist groups, political factions, and military factions; and perhaps even individuals. Each could have reasons for seeking access to nuclear weapons or their critical components.

As for countries, Colonel Qaddafi's repeated efforts to purchase a nuclear weapon for Libya are well known.** Less well known, however, were the earlier comparable efforts of former President Sukarno to purchase a nuclear weapon for Indonesia from China.*** More generally, depending upon factors discussed below, e.g., conflict-related perceptions of nuclear weapons' utility and the scope and pace of nuclear proliferation, various technologically limited countries might become active seekers of black market nuclear materials or bombs.

Sub-national groups of varying types also could emerge as buyers of stolen or diverted fissile materials or nuclear weapons if these became black market commodities. In this regard, much speculation has

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*See below, pp. 77-78.

**This, as well as other Arab attempts to purchase nuclear weapons, is reported by Steven J. Rosen, "Nuclearization and Stability in the Middle East," in Nuclear Proliferation and the Near-Nuclear Countries, Onkar Marwah and Ann Schulz (eds.) (Cambridge, Mass.: Ballinger Publishing Company, 1975), p. 178.

***William H. Overholt, personal communication to authors.

focused upon possible future efforts by terrorist organizations such as the Japanese Red Army or by political movements such as a successor to the Palestine Liberation Organization (PLO) to gain access to nuclear weapons. Two other possibilities warrant equal attention.

On the one hand, a faction of high-ranking military men in a non-nuclear-weapon state could engage in black marketeering to acquire a nuclear weapon or its critical components. They might believe that possession of a nuclear weapon would facilitate their eventual seizure of power, either by symbolizing that power had changed hands or by allowing them to coerce loyalist military forces while deterring the use of force against themselves.* Or, such a group could conclude that their ability to unveil one or more nuclear weapons--whose acquisition would have been barred to the legitimate government perhaps due to external pressure--could turn out to be critical for national survival in a future crisis or conflict. To illustrate, recognizing the constraints upon their government but fearful of the future, a high-level faction within the Taiwanese military might so conspire. The possibility of both such an attempt and its success would depend upon the adequacy of command procedures, access to needed financial resources, and, of course, available supply.**

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*For elaboration, see Lewis A. Dunn, "Military Politics, Nuclear Proliferation, and the 'Nuclear Coup d'Etat'," (Hudson Institute, HI-2392/2-P, April 20, 1976).

**One precedent for such efforts by high-level military men to ensure national survival as they view it would be the 1944 Generals' Plot against Hitler.

On the other hand, efforts to acquire nuclear weapons or their critical components via black market transactions could be undertaken by quasi-military, sub-national groups. For example, within Japan a successor group to Yukio Mishima's private army might believe national duty demanded such action, given what it would regard as the government's failure to meet its obligations to ensure the national defense. Here, too, images of their eventual emergence as national saviors would be influential. Or, in countries such as Lebanon where private armies confront each other, the motive of strengthening one's position against contending factions could suffice to precipitate such action. Again, the availability of supply, the extent of financial resources, and the potential risks of this course of action would be important determinants of whether such a potential interest ever was actualized.

Finally, wealthy individuals also might be prospective buyers, particularly of nuclear weapons themselves. Their motives could range from personal idiosyncracy--having a covert nuclear weapon in one's basement, as opposed to a rare work of art, might be considered the ultimate toy--to an intention to utilize its possession for criminal purposes.

As for potential suppliers, a variety of possibilities exist. A financially hard-pressed nuclear-facility employee gradually might divert nuclear material either to sell directly or to channel into a criminal organization serving as a "fence." Alternatively, such an individual could be an "inside contact" for a criminal group planning a major nuclear theft. Or that criminal group, motivated by financial factors, could carry out such a theft alone. Further, as argued more

fully below, if nuclear black marketeering begins to "take off" in the context of widespread commercial reprocessing and circulation of plutonium, black marketeering by either individual nuclear-industry companies or their highly-placed officials, for personal financial and/or for corporate profit motivations, cannot be precluded.*

Turning to potential categories of suppliers of stolen nuclear weapons themselves--in contrast to direct theft not for re-sale--past experience with the lack of attempts against American nuclear stockpiles suggests that criminal organizations might shy away from such theft. But that could change, especially if Nth country nuclear stockpiles provided somewhat easier targets or if the trade-offs among the risks and payoffs of such theft changed in the future. Nonetheless, a more likely supplier of black market weapons--as opposed to gray market ones, where the government itself would be engaged--could be financially ambitious and dissatisfied officers within new nuclear-weapon states.

Thus various categories of conceivable buyers and sellers can be delineated. In turn, potential networks involving both are identifiable, e.g., a transaction in which a criminal organization sold stolen fissile materials to a low-technology country. (Table 2 lists the most likely prospective buyers and sellers.)

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*The U.S. Department of Justice is conducting a large grand jury investigation into illegal transshipments of arms and ammunition to South Africa from Colt Industries and the Winchester Group of Olin Corporation, both companies having conceded that illegal shipments had occurred (but against corporate policy). A press report quoted a South African gun dealer as saying that she dealt regularly with Winchester and Colt. See The Wall Street Journal, October 21, 1976.

Table 2

POSSIBLE BUYERS AND SELLERS

BUYERS	SELLERS
LOW-TECHNOLOGY COUNTRIES	INSIDE INDIVIDUALS
SUB-NATIONAL GROUPS	CRIMINAL ORGANIZATIONS
TERRORISTS	INDIVIDUAL FIRMS
DISSIDENTS	
MILITARY FACTION	NTH COUNTRY MILITARY MEN
NON-MILITARY GROUP	
INDIVIDUALS	

Intermittent Transactions vs. Market

However, before considering the conditions necessary for the actual emergence, growth, and spread of such nuclear black marketeering, one especially critical analytic distinction--that between intermittent transactions and a full-blown market--merits brief attention. Essentially this is the distinction between non-repetitive, one-shot decisions or actions and repetitive decisions and continuing operations or activities. Put in the context of the present discussion, it is a question of whether future nuclear black marketeering entails, for example, only an isolated nuclear-material theft for sale to the highest bidder or the emergence of an intricate network for the continuing acquisition and sale of diverted or stolen fissile material. (Given supply constraints discussed below, nuclear-weapon sales nearly by definition are likely to be intermittent transactions.)

A useful analog, which may serve to flesh-out this distinction, is black marketeering within the United States during the Second World War. During that war an extensive network of sources for trading of illegal goods pervaded the American way of doing business. Repeated violations of price and rationing regulations, involving producers, wholesalers, retailers, and consumers, occurred over a wide range of commodities, including heavy materials, clothing, gasoline, tires, shoes, potatoes, cigarettes, and alcoholic beverages. Also indicative of the scope of these activities is a 1945 Gallup survey which suggested that 20 percent of the American population condoned occasional purchases on that wartime black market. That is, what is striking is the pervasiveness of the black marketeering. In other

words, the American wartime economy was operating on two levels: white market transactions in various goods and services represented the bulk of the economy, but black market transactions in violation of price, rationing, and other wartime regulations constituted a second, continuing, and not insignificant tier.*

Do foreseeable conditions exist which could produce a similar outcome in nuclear commodities? Put otherwise, what factors would determine whether and to what extent black marketeering emerges?

2. Conditions for the Emergence and Growth of Nuclear Black Marketeering

In assessing conditions which could either impede or foster nuclear black marketeering, supply-related, demand-related, and response-related factors warrant analysis. Then relationships among them can be suggested and an estimate of the likelihood of alternative levels of nuclear black marketeering made.

Supply-Related Conditions

Clearly the development of nuclear black marketeering in fissile material or its precursors presupposes the availability of materials for diversion or theft and subsequent purchase via illicit channels. If no materials were available, there would be no possibility of a black market; conversely, if an abundant supply existed, with nuclear materials freely traded in international commerce, scarcity would not be a significant constraint upon the possible emergence of such illicit

*See Marshall B. Clinnard, The Black Market: A Study of White Collar Crime (New York: Rinehart & Company, Inc., 1952), pp. 340-358, passim.

transactions. The real-world situation is likely to remain somewhere between these two extremes, with supply potential neither marginal nor superabundant.

More specifically, the extent to which various nations reprocess spent fuel to separate fissile plutonium (as well as enrichable uranium) from radioactive fission products produced in research and power reactors would be one of the primary determinants of the magnitude of potentially divertible or theft-prone nuclear materials exchanged in commercial open-market operations. If, for example, plutonium is nowhere separated from spent nuclear fuel and recycled into light-water reactor fuel or stockpiled for breeder reactors, that would drastically reduce the possibilities for its leakage onto a black market. Alternatively, if plutonium has become a normal international commodity in the sense that many countries separate it from spent fuel for near-term recycle or future utilization in breeder reactors, the development of an illicit plutonium market, perhaps using some of the sources, distribution channels, and human resources of the legal plutonium market, would be more likely.

The following tables indicate nuclear fuel reprocessing facilities in operation or planned as well as aggregate reprocessing capacity in the world under different assumptions about which countries permit reprocessing operations within their boundaries. Relative to the baseline scenario, given in Table 3, in which no constraints are imposed on the use of reprocessing plants, a second scenario for no reprocessing in both Japan and the United States would reduce annual plutonium

Table 3

NUCLEAR FUEL REPROCESSING PLANTS

COUNTRY	TYPE OF FUEL	START OF OPERATION	FEED CAPACITY (TONNE U/YR)	PU PRODUCT/YR AT CAPACITY (KG)	COMMENTS
ARGENTINA		1968	200 KG/YR	---	
BELGIUM (MOL)	Metal/LWR		80	516	167 tonnes U have been processed.
Eurochemic	MTR	1966	40	---	Eurochemic is not expected to process any more fuel.
FRANCE					
Marcoule	Metal	1958	500	2150	French military and civilian reactors.
La Hague	LWR	1975/78	400	2580	Will increase production gradually until 1978.
GERMANY					
WAK, Karlsruhe	LWR	Sept. 1971	36	232	32 tonnes U have been processed.
KEWA	LWR	1983/84	1400	9030	
INDIA					
Trombay	HWR	1967	100	230	
Tarapur	HWR & LWR		150	968	Assume all LWR fuel.
ITALY	MTR	1970	5	---	
Eurex 1	LWR	1975	10	64	

Table 3 (cont.)

NUCLEAR FUEL REPROCESSING PLANTS (cont.)

COUNTRY	TYPE OF FUEL	START OF OPERATION	FEED CAPACITY (TONNE U/YR)	PU PRODUCT/YR AT CAPACITY (KG)	COMMENTS
JAPAN					
Tokai-Mura	LWR & Nat U	1976	200	1290	Assume all LWR fuel.
SPAIN					
Moncla	MTR		100 KG/YR	---	
TAIWAN					Small pilot plant.
UNITED KINGDOM					
Windscale 1	Metal Nat U	1964	2500	10750	
Windscale 2	LWR	1970(76)	400	2580	Shut down 1973 after processing 100 Te. Will restart 1976 at 200 Te/yr and 1977 400 Te/yr.
		1982	400	2580	
Dounreay	Highly Enriched U and Pu		1	---	
UNITED STATES					
Barnwell	LWR	1983?	1500	9675	May become an ERDA demonstration plant.
West Valley	Metal, LWR	1988	600	3870	360 tonnes have been processed: 60% Hanford production fuel, 40% Low-exposure LWR fuel. Unlikely to be completed.

SOURCES: DERIVED FROM PAN HEURISTICS, MOVING TOWARD LIFE IN A NUCLEAR ARMED CROWD?, PREPARED FOR THE U.S. ARMS CONTROL AND DISARMAMENT AGENCY, ACDA/PAB-263, APRIL 22, 1976; U.S. NUCLEAR REGULATORY COMMISSION FINAL GESMO, AUGUST, 1976.

production in 1984 from 28,560 kg to 17,560 kg (see Table 4).* Similarly estimated, no reprocessing in the United States, Japan, England, and West Germany would reduce annual plutonium production in 1984 from 28,560 kg in the baseline scenario to 3,100 kg or by nearly a factor of 10. Thus, using a LEMUF** of 1 percent, the global MUF in 1984 could range from 280 kg/year in the baseline scenario, in which everyone reprocesses, to 31 kg/year if only France and Belgium reprocess spent fuel. Thus, if the United States bans nuclear reprocessing and if that has a substantial demonstration effect causing Japan, Britain, and West Germany to follow suit, the supply potential for an international nuclear black market would be reduced by nearly one order of magnitude.

Moreover, in recent months the validity of arguments advanced for reprocessing has been seriously challenged.*** Numerous parties have indicated their intent to participate in hearings during 1977 before the U.S. Nuclear Regulatory Commission on the environmental, health, safety, and safeguards implications of wide-scale utilization of plutonium in mixed-oxide fuel. At the same time, President Ford recently announced a change of policy on commercial nuclear fuel reprocessing, indicating that

> the United States should no longer regard reprocessing of used nuclear fuel to produce plutonium as a necessary and

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*The assumption is made that the demand for reprocessing services exceeds the supply, hence the reprocessing facilities operate at full capacity.

**LEMUF: Limit of Error in Material Unaccounted For.

***See generally Henry S. Rowen and Gregory Jones, Influencing the Nuclear Technology Choices of Other Countries: The Key Role of Fuel Recycling in the U.S., Pan Heuristics, PH76-08-638-14, August 6, 1976.

Table 4

ALTERNATIVE COMMERCIAL REPROCESSING SCENARIOS, 1975-84

	Aggregate Capacity (MTU/YR)			Separated Plutonium (KG-PU/YR)		
	1974	1979	1984	1974	1979	1984
WIDESPREAD REPROCESSING (Baseline Scenario)	116	1126	4426	748	7260	28560
MODERATE REPROCESSING (No reprocessing in U.S. and Japan)	116	926	2726	748	5970	17590
SPARSE REPROCESSING (No reprocessing in U.S. Japan, U.K., and FRG)	80	490	490	516	3100	3100

> inevitable step in the future development of commercial nuclear power.*

And, in his May 1976 speech at the United Nations, President-elect Carter stated that

> There is considerable doubt within the United States about the necessity of reprocessing now for plutonium recycle....Since the immediate need for plutonium recycle has not yet been demonstrated, the start-up of the [Barnwell] plant should certainly be delayed to allow time for the installation of the next generation of materials accounting and physical security equipment which is now under development.**

Thus, the likelihood that nonmilitary reprocessing of spent nuclear fuel will be permitted in the United States before 1985 appears to be low and diminishing, as does the related probability that various multinational reprocessing ventures will begin operation in the mid-1980s. The concomitant implictaions for estimating potential supplies of fissile plutonium for black market transactions have just been noted.

Assuming a sharp reduction in the magnitude of commercial transactions in plutonium, what other potential supplies of fissile material for illicit sale might exist? One possibility would entail the theft and subsequent sale of spent fuel to be reprocessed in clandestine national reprocessing facilities or sub-national group or criminal hot-cell laboratories. Once spent nuclear fuel has cooled for 150-200 days in reactor swimming pools, it can be handled with caution and could be diverted into illicit channels as a source of black market plutonium. Alternatively, as suggested above, depending upon the

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*David Burnham, "A Proposal by Ford on Nuclear Curbs is Expected Today," The New York Times, October 28, 1976.

**"Nuclear Energy and World Order." Address by Governor Jimmy Carter at the United Nations, May 13, 1976.

success and availability of advanced uranium enrichment technologies such as gas centrifuge and laser isotope separation, low-enriched uranium could become a more attractive target for nuclear black marketeers. However, with both of these alternatives, as well as that of limited commercial reprocessing of spent fuel, an assessment of potential supply would suggest that what nuclear black marketeering did emerge would fall closer to the transaction than to the market end of the continuum.

Two additional supply-related factors should be sketched briefly. On the one hand, supply potential also would depend upon the viability and effectiveness of safeguards and physical security measures for nuclear materials. Should a major safeguards agreement violation occur and not be met by an adequate response sufficient to prevent an erosion of the morale and effectiveness of International Atomic Energy Agency (IAEA) inspectors, the safeguards system could erode markedly. Countries might become less ready to cooperate with the IAEA, inspectors might become less willing to challenge possibly suspect activities, material accounting requirements might be followed less rigorously, and so on. Such a deterioration of the safeguards system's viability then not only might facilitate covert diversion by governments for their own purposes, but also could facilitate diversion by nuclear facility employees for black market sale.

Conversely, an increase in the effectiveness of existing safeguards procedures and systems, reducing the level of material unaccounted for (MUF) in the nuclear fuel cycle and otherwise restricting unauthorized access to nuclear materials, would increase the obstacles to successful

slow diversion and increase the risks of attempting it. Concomitantly, new fuel-cycle protection systems--emphasizing, for example, better containment concepts, limited personnel access, and discrete storage of only small quantities of material--would have a similar dampening impact upon potential supply. Even though such increased safeguards' effectiveness might not affect significantly possibilities for large-scale facility break-ins and hijackings, they would reduce the feasibility of "trickle theft" as a source of supply.*

On the other hand, the adequacy of physical security measures for nuclear weapons, of course, would be an important determinant of black market supply. Those measures are discussed below in the context of a consideration of nuclear-weapon theft. Suffice it to suggest here that it appears that sufficient supply to fuel a continuing market in stolen weapons--even Nth country ones--as opposed to one-shot ad hoc exchanges appears lacking.

To sum up, the most important supply-related factors influencing nuclear black marketeering clearly would be whether or not widespread global commercial reprocessing of spent fuel and circulation of plutonium occurs. Without such reprocessing, the supply potential of fissile material would be greatly reduced. In turn, the viability and effectiveness of the safeguards-physical security system for nuclear

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*During the past three years, more than a dozen scholarly papers on the statistical control aspects of this problem have appeared. In conjunction with work underway at Los Alamos Laboratory and Lawrence Livermore Laboratory to improve material control processes, this suggests that the problem is being taken seriously.

materials would appear an important, though somewhat less so, determinant of supply potential.

Demand-Related

A second set of factors influencing whether or not nuclear black marketeering emerges, and if so to what extent, would be the level of demand for illicit nuclear weapons or their critical components. How much prospective buyers would be willing to pay for black market nuclear commodities--both financially and in terms of risks assumed--would vary, of course, with their perceived potential utility and with potential buyers' perceptions of their particular need for them. Concomitantly, as demand and readiness to pay increased, so would the readiness of prospective sellers to run risks and take action to meet demand. And, a demand-induced growth of nuclear black marketeering, within limits to be discussed, could occur. Specifically, the possible impact of three broad demand-related factors should be elaborated: conflict-related perceptions of the utility of possessing nuclear weapons, the scope and pace of nuclear proliferation, and idiosyncratic occurrences.

Turning first to perceptions of nuclear weapons' utility, possible conflict-related demand on the part of both sub-national groups and various countries warrants attention. Each is discussed in turn.

Writing in the late 1960s, David Wood enumerated 128 conflicts between 1898 and 1967, with 56 classified as armed insurgency against the central government, civil war between factions, or military coups d'etat.* Moreover, as indicated above, various intra-state groups

*David Wood, Conflict in the Twentieth Century, Adelphi Paper Number 48 (London: The Institute for Strategic Studies, June, 1968), p. 19.

involved in such activities could be interested buyers of black market nuclear materials or weapons. To the extent that the pattern of intra-state conflict described by Wood continues, or even becomes more pronounced, the potential demand effected by such groups could increase. And, should one of them actually come into possession of nuclear weapons--as might occur--and use them successfully in pursuit of its objectives, other like-situated groups might be all the more ready to pay to acquire one or more nuclear weapons of their own.

Nonetheless, such warring domestic factions or comparable sub-national groups--or at least most of them--are unlikely to be rich or powerful enough to generate a sufficiently large demand to do more than foster intermittent black marketeering--assuming the previously discussed supply conditions are met. That is, this domestic conflict-related demand could be great enough to absorb the occasional output from criminally-organized nuclear theft, but possibly would not be sufficient in itself to induce development of a widespread nuclear black market with many individual diversion activities, continuing networks, and criminal organizations providing necessary middleman services.

Conversely, under certain conditions, future instances of regional warfare, or even its prospect, might generate sufficient demand to induce more widespread nuclear black marketeering and sustained efforts by potential suppliers to fill that demand. Much would depend upon whether one or both of the parties to the conflict came to believe that its relative position would be improved by acquiring nuclear weapons. One scenario envisions confrontation between Israel and Egypt in the mid-1980s in which both sides mobilize for war when Israel

suddenly detonates a clandestinely developed nuclear weapon over the Sinai, reveals it has 20 more, and forces Egypt to back down.* In that situation, a humiliated Egypt would have high incentives to acquire nuclear materials or weapons to counter the Israeli advantage. But, given limited Egyptian capabilities, as well as the need to act quickly, indigenous production might be thought too time-consuming. If, by then plutonium had become an international commodity freely traded in numerous open market transactions, Egypt might attempt to purchase diverted or stolen plutonium, perhaps with Saudi Arabian money. That is, with large sums of Arab money either used directly to suborn nuclear-facility or company employees and officials or indirectly as an enticement to criminal organizations, open market transactions in white plutonium might be diverted into illicit channels terminating in Egypt. In turn, Arab money might be used, assuming the technology were available, to establish clandestine enrichment facilities to boost stolen low-enriched uranium. Concomitantly, Arab pressures also might be exerted upon oil companies engaged as well in the nuclear business, e.g., Gulf and Exxon, for corporate concessions in the form of illicit nuclear assistance to that undertaking.

In the preceding example, actual detonation of a nuclear weapon during an intense crisis triggered efforts by the non-nuclear party to acquire illicit nuclear materials. But, in a supply environment characterized by legitimate commercial exchange of fissile material, continuing intense pre-war mobilization could come eventually to

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*This scenario was suggested by Edward Boylan.

encompass efforts to acquire black market fissile materials. At some point, one or the other side might conclude that possession of nuclear weapons would allow it to gain the upper hand. Possible cases in point, in which each side's efforts to mobilize could come to include attempted acquisition of diverted or stolen fissile material might involve Greece and Turkey, Iraq and Iran, Egypt and Libya, and Libya and Algeria. In each case, such conflict-related demand for black market fissile material or nuclear weapons would make it more worthwhile for potential sellers to attempt diversion or theft.

A second demand-related factor, partly touched upon by the preceding examples but warranting separate mention, would be the future scope and pace of nuclear proliferation. If in the 1980s-1990s a growing number of countries have begun to acquire nuclear weapons, proliferation momentum--the belief that widespread proliferation was becoming inevitable--would increase. Low-technology countries, now believing that their neighbor would "go nuclear" but unable to develop a matching capability, might seek to redress the balance by black market purchases--assuming adequate potential supply and acceptable risks. Their prospective readiness to pay might trigger efforts to meet that demand by those potential suppliers delineated earlier. Whether such countries actually pursued this course of action, however, also would depend upon the perceived risks involved and whether alternatives existed, e.g., that gray marketeering discussed below. Before turning to that, one final demand-related factor needs to be considered.

The level of demand for black market nuclear commodities also would be affected by what may be termed "idiosyncratic occurrences."

These may be defined as events which might or might not occur and over whose occurrence little influence or control exists. One is whether fears that such radical nihilist terrorist groups as the Japanese Red Army or a successor to the Baader-Meinhof Gang would be willing to use nuclear weapons prove realistic. Another concerns whether new-type terrorist groups, constituting virtual mini-states and seeking nuclear weapons, will emerge or not. Finally, there is the question of the extent to which those wealthy individuals hypothesized earlier as prospective buyers actually emerge.

Thus, in addition to supply-related conditions influencing whether and/or to what extent nuclear black marketeering develops, demand-related conditions can be delineated. Before turning to a brief discussion of their possible relationship, and a brief assessment of the likelihood of any black marketeering at all, one final element should be discussed. That is, what impact would responses to control black marketeering have upon potential buyers' and sellers' estimates of its risks and consequences?

Response-Related

As the preceding discussion of potential buyers and sellers indicated, under given conditions of supply and demand various parties might have significant opportunities and incentives to engage in nuclear black marketeering. Whether or not they would do so, however, probably would depend heavily upon their assessment of the risks and costs involved. Among the most important determinants of that assessment would be their perceptions of the likelihood and severity of the alternative responses which could range, for example, from pursuit

and capture of criminal organizations serving as suppliers to invoking severe punitive sanctions against a country that purchased stolen nuclear material or weapons. Put otherwise, although the initial incidences of nuclear black marketeering might be quite unpredictable and localized--both in terms of supply and demand--once several successful black market transactions had been consummated, the demonstration effect could produce a slow broadening of the black market. That is, if the first instances go unopposed, and assuming sufficient supply, the original transactions could grow into a nonlocalized set of networks unconnected with any specific conflicts or conflict-prone regions. Thus, a global black market to which potential proliferators and subnational groups might turn for illicit nuclear materials and expertise ultimately could result.

This possible expansion, presupposing a combination of sufficient supply, varied demand, and ineffective response, becomes clearer if we return again briefly to the discussion of the American black market in World War II. One basic problem of enforcing wartime price and rationing controls was the uniform tendency of judges to hand down light sentences to business offenders, most of whom had no criminal record. Further, many OPA enforcement lawyers were themselves rather reluctant to ask for criminal sanctions against violators out of concern that doing so could lead to the loss of potential business clients when the war ended. In that permissive climate, contacts among early black market entrepreneurs and legitimate businessmen being damaged by the wartime price and rationing controls resulted in widespread transmission

of illegal behavior and practices and their supporting rationalizations.* Thus, the potential undesirable impact of inadequate responses to precursors of full-blown black marketeering should not be overlooked.

Supply, Demand, and Response: Some Relationships

Starting from the basic distinction between an intermittent transaction and a full-blown set of market networks, the preceding discussion has analyzed various conditions for the emergence and growth of nuclear black marketeering. The level of potential activity clearly is bounded initially by supply availability, and most importantly by whether or not plutonium emerges as a standard international commodity. Within that constraint, the extent of nuclear black marketeering would be influenced by the interaction of demand and response factors. In particular, whether or not high demand develops is likely to be determined significantly by conflict-related changes in perceptions of nuclear weapons' utility and the scope and pace of future proliferation, as well as by idiosyncratic occurrences. But when the extent to which potential buyers in especially "high-demand" situations actually seek to induce or engage in black market transactions would be influenced by their assessment of the risks and costs of doing so. And a similar risk-benefit calculus would influence the extent to which potential suppliers decided to become nuclear black marketeers. Finally, in both cases a critical determinant of the risk calculus would be estimates of the likely responses to their activities and the consequences of unsuccessful nuclear black marketeering.

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*Clinnard, op. cit., pp. 298-308.

3. Likelihood of Nuclear Black Marketeering

If the preceding analysis is accurate, whether and/or to what extent nuclear black marketeering in fissile materials emerges, would be heavily dependent upon the magnitude of potential future suppliers of fissile material. More specifically, if political relationships among the supplier nations are not conducive to banning plutonium from international commerce, there appears little chance of controlling sufficiently the potential supply of black market nuclear materials. In that case, prospects for the emergence and expansion of nuclear black marketeering would depend upon the level of potential demand and the impact of actual responses, including efforts to tighten safeguards procedures and physical security measures after an initial nuclear theft. But, even the threat of severe responses might not deter hard-pressed nations in future conflict-prone or nuclearizing regions from purchasing available black market fissile materials. Nor might it suffice to alter the risk calculation of all potential sellers. Thus, to the extent that supply is not controlled, the outcome is likely to be at the very least intermittent nuclear black market transactions.*

B. Nuclear Gray Marketeering

Recently much attention has focused upon the problem of nuclear black marketeering. But, particularly if the supply potential for a black market in diverted or stolen fissile materials or weapons is held down and policy responses are adopted to make such transactions

*The consequences, detectability of, and responses to nuclear black marketeering are discussed below.

increasingly dangerous, any possible nuclear black marketeering might be limited to intermittent transactions. Somewhat more probable, by contrast, would be the emergence of extensive nuclear gray marketeering. Such gray marketeering would encompass a spectrum of activities ranging from government-to-government assistance in the development of nuclear weapons to dealings in nuclear mercenaries. Although running counter to international non-proliferation norms, these activities, and the others to be noted, would not necessarily be illegal: thus the term "gray marketeering."*

1. Types of Transactions

Turning to types of transactions, what might be exchanged, by whom, and for what types of consideration needs to be addressed. Then several possible precursors of future gray marketeering can be identified before delineating conditions for that market's emergence and growth. (An assessment of the consequences, detectability, and responses to both nuclear black and gray marketeering, to repeat, is included below.)

Gray Market Activities

Included within the spectrum of potential gray market activities would be: covert or officially unacknowledged government-to-government assistance in developing nuclear weapons; covert government-to-government

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*Depending upon the particular gray market activity, if not also upon the specific participants involved in the transaction, its precise legal status could vary. The transactions discussed below, for example, range from covert government-to-government exchanges legally permissible under each country's laws to unacknowledged circumvention of declared governmental policies by semi-official bodies within that country and include activities which may be legal under one of the participant's laws but illegal under that of the other.

exchange of fissile material and weapon-design information; the ready availability of nuclear mercenaries; and covert assistance by individual nuclear-industry firms or by unauthorized corporate officials to the nuclear-weapon programs of various countries. The following briefly examines each of the possibilities.

Covert or officially unacknowledged government-to-government assistance could range from help in developing a nuclear-weapon production capability to the transfer of advanced weapon-design information. A future new nuclear-weapon state might "second" several of its own engineers and technicians to another prospective proliferator to assist the latter in developing, for example, a production reactor or hot-cell reprocessing capability; or it might supply needed components or raw materials for building or operating either facility. In turn, for many new nuclear-weapon states, reducing the size, weight, and dimensions of their early generation nuclear warheads would be a first-order task.* More advanced new proliferators could assist others in doing so by transferring design information and test results.

Depending upon the specific countries in question and the risks involved, direct transfer of fissile material (accompanied again by weapon-design assistance) cannot be precluded. In some cases, unsafeguarded fissile material, derived from indigenously built production reactors, could be exchanged; but a more likely prospect would be for the use of formerly safeguarded material taken from newly "nationalized" reactors. Citing the legal principle of rebus sic stantibus, it would

*See Dunn and Kahn, op. cit., pp. 76-78.

be argued that due to changed conditions past legal commitments no longer were operative.

Gray marketeering also could come to encompass the buying and selling of nuclear mercenaries, individuals either with past experience in some country's nuclear-weapon program or in a related aspect of the nuclear industry. Even if these persons did not bring with them weapon-design and development information per se, they could supply needed expertise in such areas as nuclear-materials handling, metallurgy, plutonium reprocessing, and theoretical physics, to name several. In addition, they also could play a necessary middleman or coordinating role for low-technology aspirant proliferators. That is, not only would they be able to make use of the information about nuclear-weapon development already available within the open literature, but they could direct the open-market procurement of the needed components, materials, and expertise for building a production reactor and associated facilities.*

Finally, the prospect of transactions between individual nuclear-industry companies or their employees and putative proliferators also should not be overlooked. Although fissile materials might not change hands illicitly, other important proprietary information (e.g., in the field of plutonium reprocessing) of use to a potential proliferator might. Alternatively, corporate-to-country transactions might involve the covert supply of necessary technical manpower, seconded to a proliferator's program and hidden within the framework of a continuing commercial presence in the recipient country.

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*For an analysis of this approach see John R. Lamarsk, "On the Construction of Plutonium-Producing Reactors by Small and/or Developing Nations," Congressional Research Service, June 4, 1976.

Terms of Exchange

In some cases, the preceding types of gray market transactions might involve a straight financial exchange. For example, 30 kg of unsafeguarded plutonium might be sold for whatever the market would bear.

Perhaps equally often, however, barter might be involved. One possibility would entail the barter of nuclear assistance or fissile material for a scarce resource such as oil or, in the future, uranium. In addition, political barter between countries, involving the trade of gray market assistance or material for political support, is conceivable.

Further, along with possible sale or barter, joint ventures in nuclear-weapon production, especially where government-to-government transactions are involved, may occur. To illustrate, consider two prospective proliferators, neither of which has the combined technical base, industrial capacity, and access to raw materials to build by itself a production reactor. One of these two, for example, might have a growing base of trained personnel but lack access to uranium ore and high grade graphite to act as a moderator; the other might have access to needed uranium ore and petroleum from which to make the graphite moderator, but lack trained technicians and engineers. In such a situation, assuming compatible political outlooks, a nuclear-weapon joint venture could be the outcome.*

Intermittent Transactions vs. Market

As is the case of nuclear black marketeering, the distinction between intermittent transactions and a full-blown market remains a

*Pakistan and Libya or Saudi Arabia could be possible participants in such a venture.

critical one. To reiterate briefly, that is the distinction between non-repetitive, one-shot actions and repetitive activities and networks continually linking varied participants together. Before discussing the conditions which would determine the extent of future gray marketeering, several possible precursors to nuclear gray marketeering need to be noted. That is, we already may have experienced one or more gray market intermittent transactions.

Within the past year there have been assertions, denied by the Bonn Government, that covert semi-official and private West German assistance to and involvement in South Africa's development of uranium enrichment technology furthered that South African program. More specifically, in the Fall of 1975, several European newspapers and magazines published "secret" documents on this question supplied by the African National Congress and alleged to have been stolen from West German ministries and from the South African Embassy in Bonn. These documents revealed the growth after 1958 of extensive contacts between various West German semi-official bodies, e.g., the state-controlled fuel company STEAG, West German ministry members, and private West German companies and both the South African Atomic Energy Board and the South African Uranium Enrichment Corporation. Of particular interest was a letter dated July 12, 1972, from the West German State Secretary at the Ministry of Education to the president of the South African Atomic Energy Board referring to how to keep secret any West German participation in South African atomic energy matters. The Bonn Government maintains that "all speculation about cooperation between the two governments is unfounded."*

*The Observer (London), October 5, 1975.

But both the fact that West Germany's representative to the NATO Military Affairs Committee, Lieutenant General Gunther Rall, was forced to resign in 1975 after these documents revealed he had clandestinely visited South Africa as a guest of its Defense Ministry in October 1974 and the similarity between the West German "Becker nozzle" uranium enrichment process and the South African "jet nozzle" process suggest, however, that some, perhaps extensive, cooperation may have occurred.*

Other possible precursors of government-to-government gray marketeering include the training of Egyptian scientists at the Indian Bhaba Atomic Research Center at Trombay,** and reports of South African-Israeli nuclear cooperation, including the purported existence of a secret nuclear test center in South Africa at which technicians and scientists from Israel are purported to be working.***

As for precursors to the availability of nuclear mercenaries, reports exist that some of the approximately 200 European nuclear engineers cognizant of plutonium reprocessing technology are consulting in less developed countries.**** Or, to take another case, consider the decision of former Argentine President Juan Peron in 1950--soon after creation of the Argentine National Commission of Atomic Energy--to employ Ronald Richter, an Austrian emigre-scientist who had previously

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*The Observer (London), October 5, 1975; Le Monde, October 8, 1975.

**Lawrence Ziring, "Recent Trends in Pakistan's Foreign Policy," Asian Survey, Volume 2, Number 5 (May/June 1975) p. 302.

***Far Eastern Economic Review, September 10, 1976.

****Personal communication to authors.

been engaged in nuclear research in Nazi Germany. After that decision, rumors circulated in Buenos Aires of a future Argentine atom bomb. Although in this case nothing resulted and Richter was fired after two years,* future efforts to buy nuclear talent may prove more successful.

2. Conditions for Nuclear Gray Marketeering

What stands out in an assessment of the conditions for nuclear gray marketeering is the growth of potential supply, the prospect of increasing demand, and the prospective emergence of strengthened pressures upon potential suppliers to engage in nuclear gray marketeering. Given that combination, the emergence and/or growth of nuclear gray marketeering may be closely related to the difficulties confronting prospective buyers in finding a source of gray market nuclear assistance and to the character of responses to its initial emergence.

Potential Supply

At least in the early stages of nuclear gray marketeering, the most likely sources of government-to-government technical assistance, fissile materials, or weapon-design information are likely to be the initial new nuclear- and candidate nuclear-weapon states themselves. Not only are sufficient pressures, as discussed below, likely to emerge, but in contrast to the major nuclear suppliers and nuclear-weapon states--already moving within the London Suppliers Talks' framework to restrict and control nuclear exports--countervailing pressures may be absent or too weak a constraint. Taken together, the following series of tables suggest the growing, if still limited,

*John R. Redick, Military Potential of Latin American Nuclear Energy Programs (Beverly Hills: Sage Publications, 1972), p. 12.

prospective capability of such new nuclear- and candidate nuclear-weapon states to enter into gray market transactions among themselves or with even weaker candidate nuclear countries. More specifically, for many prospective early proliferators these tables depict: increasing potential access to separable plutonium; a growth of trained elite manpower represented by their students studying within the United States*; a greater capability for indigenous training of technical manpower; a changing demographic, economic, and technical base; the start of exports of engineering products by some of them; a shifting international market for engineering products which again includes the emergence of some LDCs as not insignificant engineering exporters; and a growing consumption of engineering products, itself indicative of growing momentum behind the development of a technological infrastructure in many of these countries.

*For foreign non-immigrant students in the United States engineering is the leading course of study; for American students abroad engineering ranks last.

SEPARABLE PLUTONIUM WITHIN RESEARCH AND POWER REACTOR SPENT FUEL

COUNTRY	ACCUMULATED (KG) OF SEPARABLE PLUTONIUM						WEAPON EQUIVALENTS (@ 4 KG PER)						ANNUAL PRODUCTION (KG) SEPARABLE PLUTONIUM						WEAPON EQUIVALENTS (@ 4 KG PER)					
	1974	1979	1984	1989	1994	1999	1974	1979	1984	1989	1994	1999	1974	1979	1984	1989	1994	1999	1974	1979	1984	1989	1994	1999
ALGERIA	----------						----------						----------						----------					
ARGENTINA	0	350	1,228	4,089	7,340	10,066	0	87	307	1,022	1,835	2,517	0	70	334	598	598	598	0	17	83	150	150	150
AUSTRALIA	11.9	15.4	18.9	22.4	25.9	29.4	3	4	5	5.5	6.5	7	.7	.7	.7	.7	.7	.7	.2	.2	.2	.2	.2	.2
BELGIUM	3.7	4.7	5.7	6.7	7.7	8.7	1	1	1.5	1.5	2	2	.2	.2	.2	.2	.2	.2	.08	.08	.08	.08	.08	.08
BRAZIL	0	85	866	7,101	16,874	26,619	0	21	216	1,775	4,219	6,655	0	113	329	1,715	1,949	1,949	0	28	82	429	487	487
CHILE	----------						----------						----------						----------					
CUBA	----------						----------						----------						----------					
DENMARK	9.9	13.2	16.5	19.8	23.1	26.4	2.5	3	4	5	6	6.5	.7	.7	.7	.7	.7	.7	.2	.2	.2	.2	.2	.2
EGYPT	0	0	216	1,836	3,456	5,076	0	0	54	459	864	1,269	0	0	108	324	324	324	0	0	27	81	81	81
GREECE	----------						----------						----------						----------					
INDIA	402	1,032	2,424	4,204	6,009	7,814	100	258	606	1,051	1,502	1,954	117	213	361	361	361	361	29	53	90	90	90	90
INDONESIA	0	0	216	2,592	5,202	7,812	0	0	54	648	1,300	1,953	0	0	108	522	522	522	0	0	27	131	131	131
IRAN	0	0	1,242	5,022	29,502	53,982	0	0	310	1,255	7,376	13,496	0	0	594	756	4,896	4,896	0	0	148	189	1,224	1,224
ISRAEL	18.7	27.2	33.7	648	1,188	1,728	5	7	9	162	297	432	1.7	1.7	1.7	108	108	108	.5	.5	.5	27	27	27
ITALY	935	1,941	6,099	26,024	45,929	65,834	234	485	1,525	6,506	11,482	16,459	90	243	931	3,981	3,981	3,981	22	61	233	995	995	995
JAPAN	1,460	10,126	26,585	43,705	60,855	77,945	365	2,531	6,646	10,926	15,214	19,486	694	2,528	3,424	3,424	3,424	3,424	174	632	856	856	856	856
LIBYA	----------						----------						----------						----------					
NIGERIA	----------						----------						----------						----------					
NORTH KOREA	----------						----------						----------						----------					
NORWAY	26.5	35.2	43.9	52.6	61.3	70.0	6	9	11	13	15	17	1.8	1.8	1.8	1.8	1.8	1.8	.5	.5	.5	.5	.5	.5
PAKISTAN	64	201	605	1,405	2,205	3,005	16	50	151	351	551	751	28	28	160	160	160	160	7	7	40	40	40	40
PHILIPPINES	0	0	226	1,356	5,006	12,076	0	0	56	339	1,252	3,019	0	0	226	226	730	1,414	0	0	56	56	183	354
RUMANIA	0	0	316	1,791	3,266	4,741	0	0	79	448	817	1,185	0	0	79	295	295	295	0	0	20	74	74	74
SAUDI ARABIA	----------						----------						----------						----------					
SOUTH AFRICA	0	0	513	2,220	3,930	5,640	0	0	128	555	983	1,410	0	0	342	342	342	342	0	0	85	85	85	85
SOUTH KOREA	0	281	1,951	8,457	15,287	22,117	0	70	488	2,114	3,822	5,529	0	102	650	1,366	1,366	1,366	0	25	162	342	342	342
SPAIN	588	2,613	12,192	18,636	32,101	66,446	147	653	3,048	4,659	8,025	16,612	165	1,133	2,333	2,693	2,693	6,869	41	283	583	673	673	1,717
SWEDEN	212	3,169	10,654	20,589	30,524	40,459	53	792	2,664	5,147	7,631	10,115	228	962	1,987	1,987	1,987	1,987	57	240	497	497	497	497
SWITZERLAND	622	1,617	6,366	12,271	18,221	24,171	155	404	1,591	3,068	4,555	6,043	181	347	1,011	1,190	1,190	1,190	45	868	253	298	298	298
SYRIA	----------						----------						----------						----------					
TAIWAN	5.3	206	1,961	6,241	11,198	15,478	1	51	490	1,560	2,800	3,870	2.7	206	856	856	856	856	2	51	214	214	214	214
TURKEY	0	0	0	540	1,080	1,620	0	0	0	135	270	405	0	0	0	108	108	108	0	0	0	27	27	27
VENEZUELA	----------						----------						----------						----------					
WEST GERMANY	1,657	7,621	21,683	42,782	62,697	82,612	414	1,950	5,421	10,696	15,674	20,653	376	2,067	3,212	3,983	3,983	3,983	94	517	803	996	996	996
YUGOSLAVIA	9.9	13.2	915	2,370	3,825	5,280	2	3	229	593	956	1,320	0.7	0.7	291	291	291	291	0.2	0.2	73	73	73	73
ZAIRE	----------						----------						----------						----------					

SOURCES: DERIVED FROM PAN HEURISTICS, MOVING TOWARD LIFE IN A NUCLEAR ARMED CROWD?, PREPARED FOR THE U.S. ARMS CONTROL AND DISARMAMENT AGENCY, ACDA/PAB-263, APRIL 22, 1976 AND ATOMIC INDUSTRIAL FORUM NEWS RELEASE, "NUCLEAR POWER-PLANT COMMITMENTS OUTSIDE THE U.S. CLIMB 17% IN YEAR," WASHINGTON, JUNE 2, 1976.

Table 5

FOREIGN STUDENTS IN THE UNITED STATES

COUNTRY	1972-1973		1973-1974		1974-1975
	TOTAL	ENGINEERING	TOTAL	ENGINEERING	TOTAL NON-IMMIGRANT
ARGENTINA	702	77	703	67	560
BRAZIL	1,560	266	1,713	258	1,970
CHILE	870	154	997	150	950
EGYPT	1,148	335	1,163	302	980
INDIA	10,656	4,615	10,168	3,912	9,660
INDONESIA	695	151	768	139	1,080
IRAN	7,838	3,744	9,623	4,393	13,780
IRAQ	361	103	376	93	420
ISRAEL	2,113	486	2,070	488	2,390
LIBYA	573	187	690	242	980
PAKISTAN	2,690	1,291	3,301	1,339	3,140
SAUDI ARABIA	943	297	1,074	300	1,540
SOUTH AFRICA	418	43	403	39	510
SOUTH KOREA	3,730	757	3,612	669	3,390
SPAIN	612	98	630	79	580
TAIWAN	9,633	2,676	8,416	2,018	10,250

SOURCE: OPEN DOORS, 1973, 1974, 1975; INSTITUTE OF INTERNATIONAL EDUCATION.

(1) ESTIMATES FOR 1972-1973 AND 1973-1974 INCLUDE IMMIGRANT STUDENTS.
(2) COUNTING PROCEDURE SIGNIFICANTLY MODIFIED FOR 1974-1975 ESTIMATES PROVIDING A MUCH GREATER ACCURACY IN COUNT; EARLIER YEARS INCLUDED FOR ILLUSTRATIVE PURPOSES.

Table 6

HUDSON ESTIMATE OF FOREIGN ENGINEERING STUDENTS INTENDING TO RETURN AFTER COMPLETION OF STUDIES, 1974-1975

ARGENTINA	53
BRAZIL	297
CHILE	143
EGYPT	254
INDIA	3,717
INDONESIA	195
IRAN	6,291
IRAQ	104
ISRAEL	563
LIBYA	344
PAKISTAN	1,274
SAUDI ARABIA	430
SOUTH AFRICA	49
SOUTH KOREA	628
SPAIN	73
TAIWAN	2,458

SOURCE: DERIVED FROM OPEN DOORS, 1974, 1975 USING A CONSTANT RATIO METHOD.

Table 7

INDIGENOUS TECHNICAL MANPOWER PRODUCTION (1)

POTENTIAL NTH COUNTRIES	ANNUAL OUTPUT (OF EARLY 1970S) NATURAL SCIENCE	ENGINEERS	TOTAL
Algeria	315	94	409
Argentina	617	2,486	3,103
Australia	4,704	3,288	7,992
Brazil	6,092	8,129	14,221
Chile	189	1,840	2,029
Cuba	350	646	996
Egypt	7,627	1,085	8,712
Greece	1,919	825	2,744
India	67,546	18,090	85,636
Indonesia	140	1,120	1,260
Iran	2,693	3,734	6,427
Iraq	1,305	1,069	2,374
Israel	1,378	1,003	2,381
Italy	8,214	5,727	13,941
Japan	11,031	79,638	90,669
Libya	73	88	161
Nigeria	156	60	216
North Korea	NA	NA	--
Pakistan	5,746	1,169	6,915
Philippines	1,431	4,256	5,687
Rumania	2,705	7,743	10,448
Saudi Arabia	73	82	155
South Africa	NA	NA	--
South Korea	2,968	10,080	13,048
Spain	2,657	6,332	8,989
Sweden	1,971	1,944	3,915
Switzerland	1,015	784	1,799
Syria	438	300	738
Taiwan	NA	NA	--
Turkey	2,081	3,797	5,878
Venezuela	71	664	735
West Germany	5,199	20,771	25,970
Yugoslavia	1,614	6,679	8,293
Zaire	78	71	149
Total	142,396	193,594	335,990

SOURCE: UNESCO Statistical Yearbook 1974, Table 5.3.

(1) THIS DATA REPRESENTS PRODUCTION OF COLLEGE LEVEL ENGINEERS. IT NEGLECTS INDIGENOUS EDUCATION OF TECHNICIANS AND ENGINEERING SUPPORT PERSONNEL.

Table 8

DEMOGRAPHIC, ECONOMIC, AND TECHNICAL INDICATORS FOR SELECTED NATIONS

NATION	LABOR FORCE 1980 (MILLIONS)	GNP 1974 U.S. DOLLARS (BILLIONS)	TOTAL UNIVERSITY STUDENT POPULATION (THOUSANDS)	TECHNOLOGICAL MANPOWER		BOOKS PUBLISHED IN PURE & APPLIED SCIENCE (TITLES) ('72 OR '73)
				TOTAL STOCK	RESEARCH & DEVELOPMENT	
Argentina	9.9	46.9	351	2,158,000	16,900	744
Brazil	36.6	93.2	688			712
Chile	3.9	8.5	127		6,233	148
Egypt	11.7	10.1	306		6,522	436
Libya	.6	7.5	10			16
Saudi Arabia	2.7	16.7	11			1
India	272.6	79.0	2,010	1,174,500	96,954	1,971
Indonesia	52.0	18.6	252			312
Pakistan	54.3	8.8	238			237
South Korea	13.7	15.8	230	1,056,908	8,764	1,266
Taiwan		11.4				
South Africa	8.4	29.2	83			568
Iran	10.1	35.1	115	160,372	5,753	683
Iraq	3.2	10.4	57	22,540	143	122
Spain	12.8	68.7	368		7,368	3,326
United States	94.9	1,406.6	10,000		525,700	7,912
Soviet Union	141.4	580.8	4,630	20,361,000	1,108,466	40,125
Turkey	19.8	26.8	170			1,787
FRG	27.2	365.2	662		320,000	
Yugoslovia	10.2	25.4	302	2,393,004	25,782	2,065
United Kingdom	25.8	188.6	538		150,014	8,857
France	23.4	272.4	739	1,702,260	140,424	6,422
Canada	10.2	136.6	42			760
Israel	1.4	11.2	9	76,000	3,100	336
Japan	57.4	425.9	2,000		449,621	8,826
Italy	21.5	153.3	809		61,049	1,505

NOTE: Blank spaces identify unavailable data.
Sources provided in backup material.

SOURCE: UNITED NATIONS DATA.

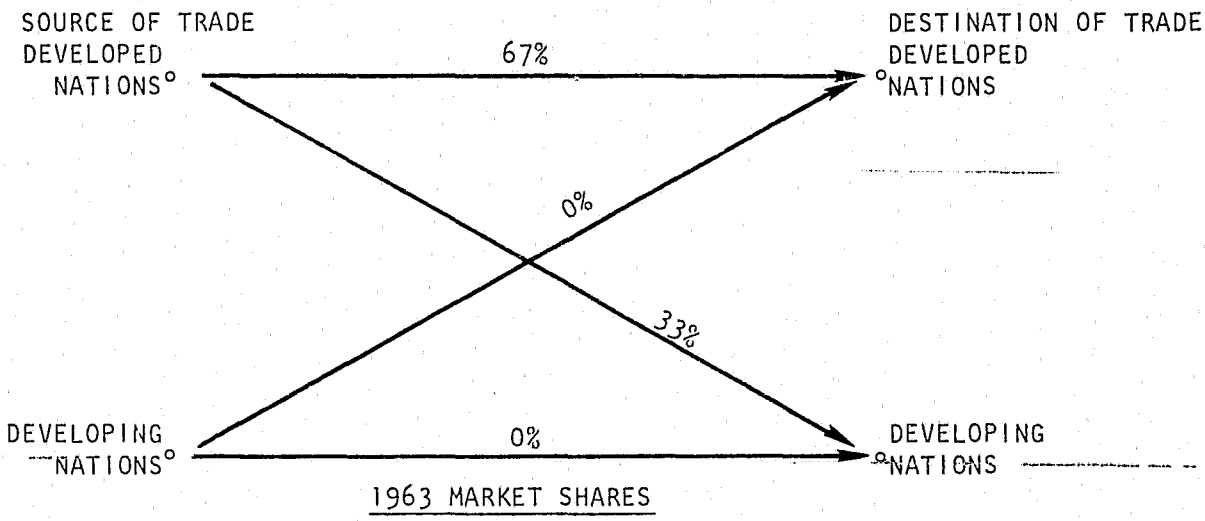
Table 9

TRADE IN ENGINEERING PRODUCTS
1974
(IN MILLIONS OF U.S. DOLLARS)

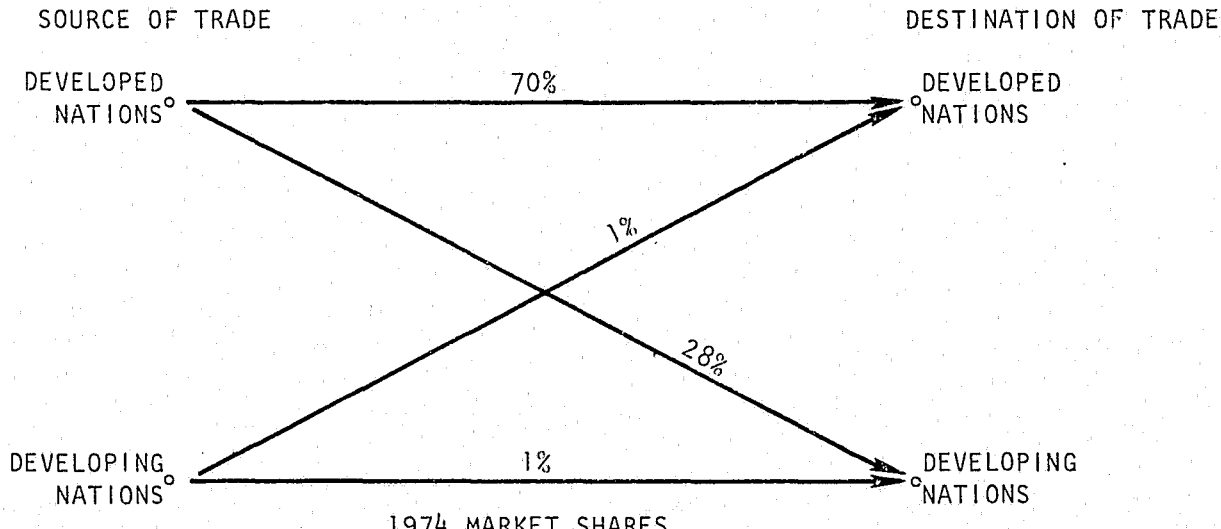
BRAZIL	SOUTH AFRICA	9.5
	LIBYA	2.1
	ARGENTINA	52.3
	CHILE	25.5
	IRAN	1.2
	ISRAEL	.9
	SAUDI ARABIA	3.1
	INDONESIA	1.8
	SOUTH KOREA	.3
	PAKISTAN	.1
	SPAIN	1.8
	TURKEY	.1
SOUTH KOREA	SOUTH AFRICA	.2
	LIBYA	1.1
	ARGENTINA	4.0
	BRAZIL	.4
	CHILE	.2
	IRAN	1.3
	SPAIN	.2
	TURKEY	.1
	YUGOSLOVIA	.4
INDIA	SOUTH AFRICA	.1
	LIBYA	2.0
	IRAN	6.8
	SAUDI ARABIA	1.8
	INDONESIA	2.8
	SOUTH KOREA	.4
	YUGOSLOVIA	3.7
ISRAEL	SOUTH AFRICA	3.1
	ARGENTINA	.3
	BRAZIL	.1
	IRAN	21.9
	SOUTH KOREA	1.3
	SPAIN	.8
	YUGOSLOVIA	.1

Table 10

INTERNATIONAL MARKET STRUCTURE
FOR ENGINEERING PRODUCTS
(Dollar Volume)



1963 MARKET SHARES



1974 MARKET SHARES

SOURCE: Hudson Calculations from United Nations data.

Table 11

GROWTH IN THE WORLD TRADE OF ENGINEERING PRODUCTS
(IN CURRENT U.S. DOLLARS)

	REGIONS OF ORIGIN	
	DEVELOPED MARKET ECONOMIES	DEVELOPING COUNTRIES
1963	$ 31.0 BILLION	.2 BILLION
1965	39.2	.3
1970	78.4	1.0
1971	91.1	1.3
1972	108.4	1.9
1973	142.0	3.2
1974	179.0	3.4

SOURCE: BULLETIN OF STATISTICS ON WORLD TRADE IN ENGINEERING PRODUCTS, ECONOMIC COMMISSION FOR EUROPE, UNITED NATIONS, E/F/R.76.11.E.7, 1976. TABLE 1A, PAGE 20.

Table 12

TRADE IN ENGINEERING PRODUCTS
(1974 TRADE IN MILLIONS OF U.S. DOLLARS)

SOURCE / DESTINATION	UNITED STATES	SOVIET UNION	WEST GERMANY	FRANCE	ITALY	UNITED KINGDOM	CANADA	JAPAN
ARGENTINA	192.9	1.9	146.3	51.6	92.5	42.9	25.9	55.6
BRAZIL	1,298.0	8.6	702.1	141.6	181.8	146.4	38.1	577.6
CHILE	139.8	---[1]	59.0	28.9	8.9	22.9	19.0	22.2
EGYPT	55.5	165.2	83.6	42.2	29.2	58.2	2.1	31.2
LIBYA	65.5	2.0	247.4	248.3	255.0	80.9	4.7	143.4
SAUDI ARABIA	424.2	1.2	177.9	50.9	57.7	135.3	9.8	298.8
INDIA	127.5	107.1	173.8	54.8	26.6	168.4	15.2	151.0
INDONESIA	236.7	5.1	200.5	61.6	29.5	64.3	8.8	602.3
PAKISTAN	145.8	14.8	58.2	28.9	20.0	66.1	8.6	98.0
SOUTH KOREA	367.8	---	90.5	24.4	11.4	70.2	7.8	1,046.5
IRAN	570.4	217.0	658.4	114.6	165.9	317.3	18.2	196.8
SOUTH AFRICA	547.5	---	839.7	202.9	193.4	652.2	39.0	455.6
IRAQ	123.6	120.3	252.8	91.9	46.4	64.9	1.1	95.9
SPAIN	584.9	3.3	840.7	464.5	385.5	230.9	29.4	114.0
ISRAEL	351.0	---	232.5	86.0	76.5	110.9	6.9	21.3
TURKEY	191.7	36.7	390.7	102.1	179.7	149.2	21.5	73.5
YUGOSLAVIA	141.1	110.8	740.2	132.7	324.3	105.5	7.9	24.4

[1]---INDICATES MAGNITUDE ZERO.

[2]DATA FOR TAIWAN NOT AVAILABLE FROM UNITED NATIONS SOURCES.

SOURCE: BULLETIN OF STATISTICS ON WORLD TRADE IN ENGINEERING PRODUCTS, 1974, UNITED NATIONS, ECONOMIC COMMISSION FOR EUROPE, E/F/R.76.11.E.7, NEW YORK, 1976.

In many, though not all transactions, such government-to-government gray marketeering would be a case of the relatively less technologically advanced helping those beneath them on the nuclear ladder or of their joining together. When considering such activities, it is useful to recall the pattern of engineering and industrial activity within many less developed countries. Many have demonstrated a marked capability to adapt used machinery to specific purposes, to make do with what is available, and more generally to fabricate "jerry-built" operations that the West would consider totally inadequate for the task at hand. Two implications of this for evaluating these countries' potential capabilities for nuclear gray marketeering need to be noted.

On the one hand, the lack of a capability to design and construct--or assist someone else in doing so--a small plutonium reprocessing plant or production reactor up to so-called Western standards, for example, should not be taken to indicate that constructing a working, if crude, facility would exceed their level of technical sophistication. On the other hand, such psychological adaptability and technical flexibility, where present, could be congenial to government-to-government nuclear gray marketeering because almost by definition such activities would involve efforts to "make do" and to create a nuclear-weapon capability with less than ideal components and designs. Both of these points, moreover, gain strength when it is recalled that the Indian plutonium reprocessing plant was just such a jerry-built affair, adapting and combining equipment available from disparate sectors of the Indian

economy.* As the following table suggests, other examples of such technical innovation and adaptability might be cited as well.

The extent to which there may exist a pool of technical, engineering, and scientific manpower from which might emerge future nuclear mercenaries also should be considered. To begin, recalling the preceding data on engineering students currently being trained within the United States, if their own countries' domestic economies prove unable to absorb them or to do so at an acceptable level of financial remuneration, they might seek employment elsewhere. And, as the following table illustrates, precedents for such migration exist.

There is another way of looking at the potential supply of nuclear mercenaries. The global nuclear industry will require approximately 115,000 trained engineers in 1980.** Even taking into account possible difficulties in training that many persons, a sizable pool of scientific and technical manpower, some of whom would be conversant with plutonium reprocessing, materials handling, and related fuel cycle technologies, can be expected to exist.

Of even greater value to a fledgling Nth country's weapon program would be individuals who had worked within the nuclear-weapon program of one of the existing nuclear-weapon countries. Depending upon such persons' level of expertise and prior responsibilities, this pool of

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*This information was conveyed to the authors by Theodore Taylor.

**See S. B. Hammond, J. A. Lane, A. Rogov, and R. Skjoeldebrand, "Manpower Requirements for Future Nuclear Power Programmes," International Atomic Energy Agency Bulletin, Volume 17, Number 4 (August 1975), pp. 16-17.

Table 13

THE INFLUENCE OF MARKET STRUCTURE AND ORGANIZATION ON TECHNOLOGICAL INNOVATION IN SELECTED LDC'S

CASE	DESCRIPTION	CHARACTERISTIC TECHNOLOGY	INFLUENCE OF MARKET STRUCTURE ON TECHNOLOGY
JUTE PROCESSING INDUSTRY IN KENYA	JUTE DELIVERED IN BALES, IS OPENED AND SPREAD, COMBED AND DRAWN. JUTE IS THEN SPREAD AND WOVEN ON LOOMS.	EXTENSIVE USE OF SECOND AND THIRD HAND MACHINERY AND EQUIPMENT.	SMALL NUMBER OF EQUIPMENT SUPPLIERS AND LACK OF BUYER ORGANIZATION LEAD TO IRREGULAR TRNASACTIONS BETWEEN BUYER AND SELLER. POOR BUYER PERCEPTIONS OF RISK AND UNCERTAINTY CREATE A NEED FOR "MIDDLE-MAN" DEALERS IN SECOND HAND EQUIPMENT.
CAN MAKING INDUSTRY IN TANZANIA	TRANSFORMATION OF TIN-PLATED SHEET STEEL VIA SPLITTING, FLANGING, AND END-SEAMING.	CAPITAL INTENSIVE MACHINERY USED.	SHORTAGE OF TRAINED, RELIABLE SUPERVISORY PERSONNEL MAKES IT DIFFICULT TO ADMINISTER A LABOR-INTENSIVE APPROACH.
COLUMBIAN ENGINEERING INDUSTRY	TRANSITION FROM PURE IMPORTATION TO DESIGNS AND INNOVATION.	DEVELOPMENT OF LOCAL CAPITAL GOODS SECTOR STIMULATES DEMAND FOR SPECIALLY DESIGNED LIGHT MACHINES.	DEVELOPMENT OF LOCAL MARKETS FOR LIGHT GOODS AND FOREIGN COMPETITION TO COLUMBIAN EXPORTS STIMULATES INNOVATIVE DESIGNS EXPLOITING COLUMBIAN INEXPENSIVE LABOR.
CIGARETTE PRODUCTION INDUSTRY IN ALGERIA	HIGH SPEED INJECTION OF TOBACCO AND PAPER WRAPPINGS.	ALL EQUIPMENT 10-50 YEARS OLD; ALL SPARES MADE BY ALGERIAN TECHNICIANS/ ENGINEERS.	SPARE PART SHORTAGES REQUIRE INDIGENOUS CAPABILITY TO COPY AND PRODUCE SPARES WITH HIGH TOLERANCES (BECAUSE OF HIGH SPEED STREAMS).
HIGH YIELDING VARIETIES (HYV) OF CROPS IN PAKISTAN	INTRODUCTION OF HYV'S REQUIRE INTENSIVE CARE, MORE WATER, FERTILIZER.	GROWTH OF LARGE SHOP INDUSTRY (10 MAN) FOR CONSTRUCTION, MODIFICATION, AND MAINTENANCE OF WATER PUMPS, DIESAL MOTORS, TUBE WELLS, ETC.	GOVERNMENTAL BUREAUCRACY INCAPABLE OF CENTRALIZED DIRECTION FOR THIS SUPPORT INDUSTRY; SHOP INDUSTRY (DECENTRALIZED) DEVELOPS WITHOUT GOVERNMENT ACTION OR EVEN KNOWLEDGE.

SOURCES: CASES SELECTED AND ANALYZED BY HUDSON INSTITUTE ECONOMIC DEVELOPMENT GROUP; TECHNOLOGY AND EMPLOYMENT IN INDUSTRY, EDITED BY A. A. BHALLA, INTERNATIONAL LABOR OFFICE, GENEVA, 1975.

Table 14

PRECEDENTS FOR THE MIGRATION AND MOBILITY OF TECHNICAL MANPOWER

	ENGINEERS	NATURAL SCIENTISTS
TO UNITED STATES, 1962-1966, FROM DEVELOPING NATIONS	19,055	7,793
TO UNITED STATES, 1972, FROM TAIWAN, INDIA, PAKISTAN, AND SOUTH KOREA	3,716	1,371
TO ISRAEL, 1967-1968, FROM UNITED STATES*		~3,000

*OF WHICH THE NEW YORK TIMES [FEBRUARY 28, 1972, PAGE 2] SAID "...IS QUIETLY EMERGING AS ONE OF ISRAEL'S MOST IMPORTANT NATIONAL ASSETS FOR DEVELOPING THE COUNTRY'S LONG-RANGE POTENTIAL."

SOURCE: BRAIN DRAIN: A STUDY OF THE PERSISTENT ISSUE OF INTERNATIONAL SCIENTIFIC MOBILITY. PREPARED FOR THE SUBCOMMITTEE ON NATIONAL SECURITY POLICY AND SCIENTIFIC DEVELOPMENTS OF THE COMMITTEE ON FOREIGN AFFAIRS, U.S. HOUSE OF REPRESENTATIVES, U.S. GOVERNMENT PRINTING OFFICE, WASHINGTON, SEPTEMBER 1974.

"potential" nuclear mercenaries could number from tens to thousands. Even though virtually all of these persons would likely refuse any offers to sign on as scientific mercenaries, that some might consider doing so cannot be precluded.

One final aspect of the potential supply of nuclear mercenaries should be noted. Within the major industrialized nuclear suppliers there exists a group of professional nuclear scientists and engineers whose careers have been tied to the prospect of future plutonium reprocessing. If non-proliferation politics and environmental litigation kill plutonium as a primary energy fuel, the combination of career shock and economic necessity might tempt or force some of these people to seek plutonium-related employment in other countries or to sell themselves as nuclear mercenaries.

Thus, potential supply, in contrast to the case of black marketeering, may be a less critical impediment to nuclear gray marketeering. In particular, the increasing accumulation of plutonium-bearing spent fuel and the growing technological and manpower base of many prospective proliferators probably would suffice to permit them to enter into gray market transactions with other countries. At the same time, a growing pool of potential nuclear mercenaries, comprised of former nuclear weapon designers and technicians, surplus engineering manpower, and unemployed nuclear engineers, is not unlikely.

Ready Demand

The emergence and/or growth of nuclear gray marketeering, of course, presupposes a demand for nuclear weapons on the part of low-technology countries or countries characterized either by uneven technological

development or specific resource or material scarcities that might lead them to consider joint nuclear-weapon ventures with similar prospective proliferators. Without reiterating the earlier arguments, suffice it to suggest that here, too, the key determinants of such demand would be conflict-related perceptions of the utility of nuclear weapons, on the one hand, and the scope and pace of proliferation, on the other. Moreover, should both increase within the next decades--which could occur--so would the likelihood of growing nuclear gray marketeering.*

Pressures for Gray Marketeering

A broad range of economic, political, and international pressures upon prospective suppliers could contribute to the emergence and growth of nuclear gray marketeering. Each category is discussed in turn.

Turning first to possible economic pressures, the potential attractiveness to a new nuclear-weapon state of selling technical assistance or personnel--or perhaps the weapons themselves, or their critical components--to other prospective proliferators in order either to reduce the financial costs of its existing program or to make feasible a more ambitious program should not be overlooked. This also might be a reason for engaging in joint nuclear-weapon ventures.

Alternatively, such assistance or weapons might be bartered for other vital resources. To a future Indian government, for example, India's nuclear expertise might come to be viewed as a "service good" to be traded for oil with one or more Arab countries. In fact, nuclear

*That likelihood, of course, also depends upon the pressures for gray marketeering, difficulties in establishing buyer-seller contacts, and possible responses to initial gray market transactions. These are discussed below.

gray market transactions even could be regarded by a future proliferator as a means of raising financial resources to pursue its economic development objectives. Why, such a country might ask, should it eschew that opportunity when many of the industrialized powers engage in commercially motivated sales of conventional arms to conflict-prone regions?

In addition, pursuit of commercial advantage could lead private companies within the major nuclear exporters, seeking to influence nuclear imports decisions within various countries, to engage in gray market transactions, e.g., by providing covert plutonium reprocessing technology. Or, that company or its officials might be forced to do so in order to do business there, just as doing business in many foreign countries now requires or entails giving monetary bribes to key officials.* As for possible nuclear mercenaries, the prospect of personal financial gain clearly would be an important incentive for them.

Under some conditions, ad hoc pursuit of narrow political advantage also might lead a state to engage in gray marketeering. For example, in the eyes of a future nuclear-armed Pakistan, one means of acquiring or solidifying Arab, or perhaps Iranian, political support in its confrontation with India might be seen to be the provision of technical assistance, if not the sale of one or more nuclear weapons. Conversely,

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*Recently it has beer revealed that such American corporations as Lockheed, Boeing, Gulf, Goodyear, ITT, Westinghouse, and General Tire have made "questionable" payments to foreign officials. Frequently such payments resulted from prior pressures from these foreign officials. Gulf Oil Corporation, for example, maintains that South Korean officials demanded the $4 million in political contributions that it made. Comparable activities by Japanese, Taiwanese, and European businessmen have been reported. The New York Times, "The Week in Review," November 14, 1976.

India might find itself ready to trade such assistance for Arab or Iranian non-support of Pakistan. And, reciprocal fears in India and Pakistan that the other might be thinking about how to use its nascent nuclear-weapon potential as an export commodity would increase the pressure on each to do so first. "Preemptive gray marketeering" could be the result.

Broader international trends also could either increase or engender pressures for gray marketeering. On the one hand, if current developments continue, Israel, South Africa, and Taiwan are likely to become increasingly isolated within the international community. Should they truly become threatened as international outcasts, they might join together in something thus equaling a "pariah international." Building upon and transforming existing linkages among them--e.g., South African-Israeli cooperation in the fields of advanced scientific technology, conventional arms, and perhaps nuclear undertakings and Taiwanese purchase of uranium from South Africa*--this group might give serious consideration to nuclear-weapon cooperation and transactions. If such a "pariah international's" emergence was forced upon these states, moreover, its existence and cooperation in nuclear matters might stimulate other countries to think about comparable gray market activities.

On the other hand, as argued elsewhere in detail,** a marked erosion of American alliance credibility could increase significantly West German incentives to acquire nuclear weapons. Fear of the Soviets, however,

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*The New York Times, April 18, 1976; The Economist, April 17, 1976, and August 28, 1976; The Far Eastern Economic Review, September 10, 1976; The Wall Street Journal, October 26, 1976.

**Dunn and Kahn, op. cit., pp. 48-51.

might constrain that decision and perhaps lead first to West German efforts to develop a covert nuclear-weapon capability before launching a full program. Such a capability to be unveiled suddenly might be thought necessary and sufficient to preclude Soviet preemption. One possibility would involve a covert gray market joint venture with either Brazil or South Africa. And, as the following table indicates, extensive contacts between these countries, which might be used to hide the presence of illicit activities, already exist.

One final international trend that paradoxically might foster the emergence and growth of nuclear gray marketeering could be the very efforts of the major nuclear suppliers to tighten controls and safeguards over their nuclear exports. To illustrate, the major nuclear exporters are reported to have agreed to require that present nuclear importers pledge that any re-exported facilities, materials, or technology would be subject to IAEA safeguards. But, covert gray market dealings could result were presently unforeseeable political or economic circumstances to lead a country such as Iran or Brazil to renege on this earlier guarantee.

Alternatively, assuming the existence of an export moratorium on sensitive facilities adhered to by the governments of the major suppliers and the growth of intense commercial pressures, individual private firms or employees therein might engage in proscribed technology transfers, contradicting their own governments' policies, as a means of attaining a competitive edge. And the oligopolistic character of the nuclear exports market could encourage such behavior.

Table 15

TRADE IN ENGINEERING PRODUCTS
(1974 TRADE IN MILLIONS OF U.S. DOLLARS)

SOURCE / DESTINATION	UNITED STATES	SOVIET UNION	WEST GERMANY	FRANCE	ITALY	UNITED KINGDOM	CANADA	JAPAN
ARGENTINA	192.9	1.9	146.3	51.6	92.5	42.9	25.9	55.6
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LIBYA	65.5	2.0	247.4	248.3	255.0	80.9	4.7	143.4
SAUDI ARABIA	424.2	1.2	177.9	50.9	57.7	135.3	9.8	298.8
INDIA	127.5	107.1	173.8	54.8	26.6	168.4	15.2	151.0
INDONESIA	236.7	5.1	200.5	61.6	29.5	64.3	8.8	602.3
PAKISTAN	145.8	14.8	58.2	28.9	20.0	66.1	8.6	98.0
SOUTH KOREA	367.8	---	90.5	24.4	11.4	70.2	7.8	1,046.5
IRAN	570.4	217.0	658.4	114.6	165.9	317.3	18.2	196.8
SOUTH AFRICA	547.5	---	839.7	202.9	193.4	652.2	39.0	455.6
IRAQ	123.6	120.3	252.8	91.9	46.4	64.9	1.1	95.9
SPAIN	584.9	3.3	840.7	464.5	385.5	230.9	29.4	114.0
ISRAEL	351.0	---	232.5	86.0	76.5	110.9	6.9	21.3
TURKEY	191.7	36.7	390.7	102.1	179.7	149.2	21.5	73.5
YUGOSLAVIA	141.1	110.8	740.2	132.7	324.3	105.5	7.9	24.4

[1]---INDICATES MAGNITUDE ZERO.

[2]DATA FOR TAIWAN NOT AVAILABLE FROM UNITED NATIONS SOURCES.

SOURCE: BULLETIN OF STATISTICS ON WORLD TRADE IN ENGINEERING PRODUCTS, 1974, UNITED NATIONS, ECONOMIC COMMISSION FOR EUROPE, E/F/R.76.11.E.7, NEW YORK, 1976.

Constraints upon a Take-off of Nuclear Gray Marketeering

By the early 1980s, a combination of growing potential supply, ready demand, and varied pressures upon potential suppliers could result in the emergence of nuclear gray marketeering. However, limits to the range of plausible buyer-seller combinations, difficulties in establishing contact between buyers and sellers and especially between prospective nuclear mercenaries and their future employers, and the effectiveness of responses to initial gray marketeering by anti-proliferation forces all would influence its eventual scope.

To begin, with the partial exception of hiring nuclear mercenaries, these gray market transactions may presuppose a preexisting framework of buyer-seller interaction. For example, under sufficient pressures, Pakistan might provide nuclear assistance to Iran or contemplate joint production of nuclear weapons with an Arab country. But Pakistan's assistance to Iran would be designed to solidify a prior "alliance" connection while the demarche to the Arab world would build upon both Moslem ties and prior military support for Persian Gulf countries.* Similarly, a candidate proliferator in attempting to gain assistance from a private corporation or its representatives probably would be limited to contacting those that already were seeking to sell it legitimate nuclear exports and over which some leverage existed. Alternatively, a new proliferator contemplating the sale or barter of nuclear assistance or fissile materials undoubtedly would exchange either of these only with a country whose political outlook and interests were compatible

*The Financial Times, August 11, 1975.

with its own. Thus, although a criminal organization might sell diverted fissile materials to anyone who could pay, many gray market transactions appear plausible only among a more limited set of "compatible" buyers and sellers.

In addition, possible difficulties in setting up buyer-seller relationships, particularly in the case of nuclear mercenaries, also might impede the growth of gray marketeering. To illustrate, assuming that both the nuclear mercenary and his prospective employer would want to avoid publicizing their respective positions, how would they come into contact with each other? Advertising such as that used in recruiting more conventional mercenaries would have to be excluded. Eventually a word-of-mouth network might develop--with one nuclear mercenary informing other potential recruits of employment possibilities--but here the risk of contacting someone who would report that initiative to the appropriate authorities might be a dampening factor. In the case of other gray market transactions, a comparable problem--willing buyers and sellers unknown to each other--could exist.

Nonetheless, the preceding hypotheses should not be taken too far. Even granting that the set of plausible buyer-seller combinations would be bounded by political compatibility, economic linkages, and past contacts of various types and that bringing buyers and sellers together could pose problems, many discrete transactions theoretically still could arise and flourish. Whether this actually occurred would depend largely upon how non-proliferation forces responded.

More specifically, such initial gray market transactions, if left unopposed, could result in more extensive gray marketeering, involving both a growing number of buyer-seller combinations and more extreme types of transactions. That is, on a government-to-government level, sale or barter of technical assistance and the launching of joint ventures might soon be followed by the transfer of fissile materials if not the weapons themselves. In turn, within a "permissive environment," individual scientists and technicians could become more inclined to sell their knowledge and services to prospective proliferators. Concomitantly, individual firms or their employees, less fearful of the consequences of doing so, more readily might contemplate offering "gray market bribes" as "sweeteners," just as money was used in the past. Given these potential ramifications of an ineffective response, therefore, careful consideration along the lines discussed below of how to respond to initial instances of nuclear gray marketeering is mandatory.

3. Likelihood of Nuclear Gray Marketeering

The term nuclear gray marketeering purposefully has been left rather loose. It is designed to focus attention upon a spectrum of activities, ranging from covert government-to-government nuclear-weapon assistance to support for the nuclear-weapon program of a possible client by high corporate officials acting without corporate approval. Each type of activity warrants serious examination. To depict these potential activities is not idle speculation; pressures for such nuclear gray marketeering already are discernible and are likely to intensify should additional proliferation occur. If nuclear gray marketeering is to be kept from taking-off, it is not too soon to begin considering appropriate policy responses.

C. Consequences, Detectability, and Responses

The importance of efforts to prevent the emergence or slow the growth of nuclear black and gray marketeering becomes evident once their likely consequences are depicted. Then some of the difficulties of detecting such transactions and a framework for identifying potential policy responses usefully can be discussed.

1. Consequences of Nuclear Black and Gray Marketeering

The emergence and growth of nuclear black and/or gray marketeering would be a proliferation turning point. The scope, pace, characteristics, and problems of proliferation all would be affected adversely.

Impact upon the Scope of Proliferation

The emergence and growth of nuclear black and gray marketeering would increase the scope of future proliferation. On the one hand, by making nuclear weapons, their critical components, or the requisite production capabilities available to countries lacking a nuclear infrastructure but ready to pay a political, economic, or financial price for access to both, they would directly augment that scope. Low-technology countries that otherwise would have been unable to "go nuclear" now would have that option opened for them. On the other hand, the emergence of nuclear black and gray marketeering would stimulate proliferation momentum, helping to create a belief that widespread proliferation was becoming unavoidable. Intensified proliferation momentum then could result in some countries, otherwise unlikely to be attracted to nuclear weapons, deciding to acquire them because "everyone else was going to do so."

Accelerating the Pace of Proliferation

The pace of future proliferation also would be accelerated for various reasons. To begin, the availability of outside technical assistance--whether from a friendly government, nuclear mercenaries, or unauthorized corporate action--let alone of nuclear weapons or fissile materials would remove the technical hurdles confronting many candidate nuclear-weapon states. As a result, their decisions to "go nuclear" could be hastened.

When discussing possible future proliferation trends, the existence of potential nuclear proliferation chains linking specific countries together must not be overlooked.* And given those linkages, a decision by one country to acquire nuclear weapons probably would have a multiplier-effect, triggering a series of other nuclear-weapon decisions in the near term. If so, nuclear black and gray marketeering, by facilitating that initial event, also could increase indirectly the pace of proliferation. A Middle Eastern proliferation chain, encompassing Libya, Egypt, Israel, Iraq, Syria, Saudi Arabia, and Iran and triggered by Colonel Qaddafi's successful access to black- or gray-marketed nuclear weapons or their components, would be a possible case in point.

Finally, the importance of nuclear black and gray marketeering's impact upon proliferation momentum should not be overlooked. By stimulating the belief that the non-proliferation regime was crumbling, and that more countries were likely to "go nuclear," and sooner, both would add again to the pace of proliferation. In particular, reciprocal pressures to proliferate preemptively--e.g., in Argentina or Brazil--

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*See Dunn and Kahn, op. cit., Part II.

by jumping the gun upon a regional rival's nuclear-weapon program, would be reinforced.

Characteristics of Proliferation

Nuclear black and gray marketeering also would have direct and indirect effects upon the characteristics of future proliferation. Black market sale of fissile materials or nuclear weapons would increase the likelihood that at least some sub-national groups--whether terrorists, political factions, or military cliques--would come into control of nuclear weapons. Nuclear gray marketeering might have a comparable, if more indirect, impact. More specifically, the likelihood of non-governmental access to nuclear weapons appears to be related closely to the number of countries that eventually decide to "go nuclear." In part this stems from the general increase in opportunities for nuclear theft or unauthorized access in a world of many more nuclear-weapon states. However, it also has to do with the possibility, which can only be alluded to here,* that for technical and political reasons command and control procedures within many of these new proliferators would be inadequate. Thus, by increasing proliferation's scope, gray marketeering indirectly adds to the likelihood of unauthorized access by sub-national groups.

Nuclear gray marketeering can be expected to change the characteristics of proliferation in another way as well. More specifically, given the availability of gray market inputs, e.g., metallurgical techniques, electronics, instrumentation and monitoring equipment, and principles of

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*See below, pp. 77-78.

advanced weapon design, low- to medium-technology countries that already had decided to "go nuclear" would be able to acquire more "sophisticated" nuclear forces than otherwise might have been feasible. The broader implications of such technical assistance appear mixed. The help of competent and experienced nuclear mercenaries, for example, might allow prospective proliferators to acquire more militarily effective and usable nuclear forces. Concomitantly, however, such forces might be less accident-prone and subject to better command and control procedures. In one regard, nonetheless, nuclear gray marketeering of this sort could be highly destabilizing. Should it come to include dealings in new uranium enrichment technologies and the sale or transfer of highly sophisticated weapon-design information--whether from another government or by the hiring of certain nuclear mercenaries--prospective proliferators then might be able to develop fusion weapons more rapidly. Conversely, without such outside intervention, many, if not most, future Nth countries are likely to be limited over the next 10-20 years to the development only of fission weapons. Such a change would be a fundamental one.

Impact upon Efforts to Manage in a Proliferated World

Perhaps most importantly, not only would the emergence and growth of nuclear black and gray marketeering increase the scope, accelerate the pace, and change the characteristics of proliferation, but these changes in turn would exacerbate the problems of managing in a more proliferated world. Each aspect can be discussed briefly.

Notwithstanding the preceding references to managing in a proliferated world, alternative possible proliferated worlds, some more dangerous

than others, can be distinguished. They would differ both in terms of the scope of proliferation and the type of nuclear-weapon programs pursued. The least undesirable alternative would be one with few new nuclear-weapon states most of which were satisfied with non-operational "in the business" prestige forces. Conversely, as more countries decided to "go nuclear" and then attempted to develop "serious" (but possibly technically deficient) nuclear forces, the risks would grow. But, as just discussed, nuclear black and gray marketeering would increase the scope of proliferation, thereby exacerbating the problems of proliferation.

And, as argued in detail elsewhere, a more proliferated world is likely to be a nasty and dangerous place, posing threats to virtually all nations.* These threats would range from the prospect of local small power nuclear wars to the risk of spreading global confrontation and conflict growing out of superpower involvement on different sides of such local nuclear disputes. Managing in such a world would require coming to understand its problems and flash-points, modifying present national and international practices, and, more generally, adapting to changed circumstances. But by accelerating the pace of proliferation, nuclear black and gray marketeering would reduce the learning time available for the superpowers and other nations to adapt successfully.

Finally, as proposed above, nuclear black and gray marketeering would increase significantly the likelihood of non-governmental access to nuclear weapons. Such a change in the possible characteristics of proliferation

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*See Dunn and Kahn, op. cit., Part IV; also see Lewis A. Dunn, "Managing in a Proliferated World," (Aspen Workshop in Arms Control, forthcoming).

would entail a greater risk of future nuclear terrorism, nuclear extortion, anonymous nuclear use, and the nuclearization of internal political conflict. More importantly, efforts to deal with the threats posed by such non-governmental access could well result in the adoption of measures profoundly antithetical to liberal democratic values and procedural norms. Civil liberties in areas such as search and seizure, coerced confessions, and privacy, to name several, all could be eroded.* For this reason, as well, the adverse impact of nuclear black and gray marketeering upon the problems of proliferation must be a cause for concern.

2. Detectability

A complete assessment of the detectability of nuclear black and gray market transactions would exceed the scope of this study, whose main purpose has been to examine and evaluate the characteristics, conditions, consequences, and likelihood of these two phenomena. However, two aspects of detectability should be touched upon: likely impediments to the detection of nuclear gray marketeering arising from legitimate nuclear and engineering transactions and, concomitantly, the probable need for human intelligence-gathering operations to penetrate that "noise."

On the one hand, efforts to detect nuclear gray marketeering may well be hindered by the "noise" created by growing trade and by the migration of trained manpower among many countries. By way of illustration, the growth of manpower migration, frequently among countries that could be classified as prospective proliferators, can be considered briefly.

*See Dunn and Kahn, op. cit., pp. 89-90, pp.132-133. On the civil liberties implications of harsh and possible preemptive police action within an emerging plutonium economy in response to a nuclear theft and/or threat, also see J. Gustave Speth, et al., "Plutonium Recycle: The Fateful Step," Bulletin of the Atomic Scientists, November, 1974.

The inflow of engineering talent to the oil-producing countries, the growth of world trade in engineering products, and the even faster growth of multinational corporations are all important factors stimulating such migration of highly trained technical manpower. For example, the Pakistani government recently clamped down on the flow of her engineers to the Persian Gulf oil-producing areas. Although unable to employ them at home, the government believed that foreign nations should not reap this technical knowhow so easily. Similarly, recent trade agreements between Brazil and South Korea with Iraq and Iran, respectively, designed to offset the increased cost of oil, probably will introduce their engineers into the Middle East. Or, to take the case of Libya, over one third of the total labor force in Libya is of foreign nationality, with projections for 1980 indicating a probable increase to forty percent. Moreover, many of these persons will be engineers working on developing Libya's infrastructure as well as her oil-export industry.*

But because of this enormous growth in the exchange of technical personnel, illicit nuclear-program activity between potential gray marketeers would be increasingly difficult to detect. These new linkages, as well as others involving trade in engineering products, could serve to hide or divert attention from nuclear-development activities.

On the other hand, penetrating the "noise" within which prospective proliferators could hope to hide gray market transactions probably would depend in good measure upon the quality of available human intelligence sources. As United States Arms Control and Disarmament Agency Director

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*On these manpower flows, see The New York Times, February 8, 1976, and August 27, 1976.

Fred Ikle testified nearly one year ago, "[i]ntelligence about proliferation, therefore, cannot be divorced from intelligence about people, and by people."* At a time when the functions of and oversight procedures for the American intelligence community are being reassessed and revised, the implications of this requirement need to be considered more fully. Whatever new arrangements evolve, sufficient scope for such proliferation-related intelligence activities needs to be retained. But at the same time, the intelligence agencies themselves may have to be prodded to take seriously the need for continuous intelligence-gathering about the possible emergence of nuclear black and gray market networks.

3. Responses to Nuclear Black and Gray Marketeering

By way of concluding this discussion of purchase, barter, or joint production as a route to nuclear weapons, the following table sets out a framework for analyzing possible responses to nuclear black and gray marketeering. No attempt will be made here to discuss all of its aspects; instead the purpose is to stimulate further thinking on this issue.

A first line of response, already touched upon above, would involve efforts to gather intelligence about nuclear black or gray market transactions. Such intelligence would be useful both for adopting preventive measures or taking prior counteraction in the case of unconsummated transactions or plans and for responding afterwards in an attempt to limit the damage already done. To the extent feasible, pooling of

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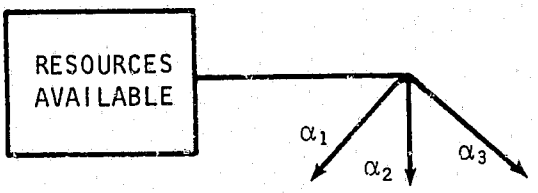
*Testimony of Fred C. Ikle before the Subcommittee on International Security and Scientific Affairs of the Committee on International Relations, House of Representatives, 94th Congress, 1st Session, November 5, 1975, p. 218.

Table 16

FRAMEWORK FOR RESPONSE ANALYSIS



$\alpha_1 + \alpha_2 + \alpha_3 = 100\%$

BRANCHING FRACTIONS
E.G., HIGH-MEDIUM-LOW

1 2 3

INTELLIGENCE RESPONSES (DATA BANKS, SPIES, SURVEILLANCE DEVICES)	TARGET HARDENING RESPONSES (ALARMS, VAULTS, PHYSICAL SECURITY FORCES, PAL)	POLITICO-MILITARY RESPONSES (NO PU RECYCLE, HEAVY SANCTIONS, DEFUSING PRESSURES, POLICE WORK, BLACK ACTIVITIES)
* POOR FOR SURPRISE ATTACKS	* GOOD FOR SURPRISE ATTACKS	* POSSIBLE HIGH POLITICAL COSTS
* CATCHES INSIDERS	* VULNERABLE TO INSIDERS	* NEED BROAD STRATEGIC & POLITICAL INFORMATION
* REQUIRES INFORMATION ABOUT PEOPLE, E.G., BEHAVIOR PROFILES, WATCH LISTS	* NEED ENGINEERING INFORMATION ON FUEL CYCLE, INTERDICTION POINTS	* VERY CONTEXT DEPENDENT
* POSSIBLE CIVIL LIBERTIES SPILLOVERS	* CONTEXT INDEPENDENT	

intelligence data among countries committed to non-proliferation would be useful; and some thought about how best to accomplish this appears appropriate.

One potential difficulty with such intelligence gathering and storage, however, should be noted and ways of reducing its impact sought. Some of these measures, e.g., computer-storage of dossiers on former nuclear-weapon designers or nuclear engineers with critical skills, as well as efforts to track their movements, probably would be in tension with important civil liberties. Here, too, therefore, additional detailed analysis of the potential civil liberties spillover of different intelligence measures and of the relative weighting of each case would appear warranted.

A second realm of responses, particularly in relation to possible black market theft or diversion of fissile materials or nuclear weapons, would entail target-hardening. Recent and projected efforts to increase the rigorousness of physical security systems within the nuclear industry would fall under this category. So would measures designed to increase safeguards viability and effectiveness. As suggested earlier, however, such measures, taken alone, appear unlikely to be able to preclude the emergence of at least some instances of nuclear black marketeering.

Perhaps most important, a broad range of politico-military responses can be identified. Possible responses might include a readiness to adopt sanctions against countries engaged in nuclear gray marketeering, police work to capture black marketeers, passage (where needed) and rigorous enforcement of legislation prohibiting the activities of potential nuclear mercenaries and controlling corporate policy abroad, and perhaps even

such black activities as the kidnapping of nuclear mercenaries or black marketeers.*

In addition, however, serious consideration should be given to reducing more directly the potential supply of black or gray market nuclear materials. Spent fuel might be bought back from other countries, preventing the accumulation of stocks which could eventually find their way into gray market exchanges. Tight controls over the dissemination of new enrichment technologies to preclude their contributing to a black market in boosted low-enriched uranium could be adopted. Above all, measures to avoid the emergence of plutonium as a freely-traded international commodity could be pursued. That is, given the risks associated with movement into the "plutonium economy"--and in particular its impact upon the likelihood of growing nuclear black marketeering--the possible costs of a decision not to reprocess and recycle plutonium readily might be outweighed by the risks of doing so.

Finally, efforts to reduce the demand for nuclear weapons clearly are needed. At this point, politico-military responses to nuclear black and gray marketeering blend with other foreign policies designed to reduce the level of regional and international tensions and conflict and with more specific non-proliferation policies designed to reduce proliferation pressures.

One final point germane to this discussion of possible responses is in order. Under certain conditions, as argued earlier, initial

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*On such possible counter-conventional strategies and black activities, see Yehezkel Dror, Crazy States (Lexington, Mass: Heath Lexington Books, 1971).

instances of nuclear black marketeering, and to an even greater extent of gray marketeering, threaten to emerge in the 1980s. Actions along the lines just considered could reduce the likelihood of these eventualities. But even should it prove impossible to prevent some initial transactions, measures such as those sketched here still might suffice to hold in check the extended growth of nuclear black and gray marketeering.

III. THEFT OF NUCLEAR WEAPONS

Recently much attention has focused upon the possible direct theft of one or more nuclear weapons, whether by political terrorists, other sub-national groups, or even a prospective aspirant nuclear-weapon state. This part of Hudson's report briefly discusses the security of American nuclear weapons abroad before taking up the question of possible theft of weapons from new nuclear-weapon states' arsenals. The latter problem, though usually overlooked, could be especially troublesome should more widespread proliferation occur in the coming decades.

A. Security of American Nuclear Weapons

1. Protection Systems

The United States armed forces currently have several thousand nuclear weapons located outside the continental U.S. These weapons vary from relatively small low yield tactical devices to high yield nuclear gravity bombs. All have sophisticated and highly redundant subsystems to prevent their unauthorized use. Such subsystems are designed to allow safing and arming of the weapon for only a narrow range of environmental conditions. For example, nuclear artillery rounds might contain built-in accelerometers that arm the shell only under the conditions of the very high accelerations that would accompany firing the round from an artillery tube.

It is important to recognize that such safing and arming devices are distinct from the various schemes designed to prevent unauthorized control of the weapon. The now rather widely known "two key" system and the use of permissive action links (PAL) provide another redundant layer of control of American nuclear weapons. An additional protection

system consists of the guarding of nuclear-weapon storage sites. If possible, these sites are located on existing military installations in order to benefit from the increased security expected on such a reservation. But military and political constraints sometimes make this impossible. An example would be the need to have the capability for nuclear firepower in an area remote from large bases and support facilities. In instances such as these, special physical protection facilities are constructed. Invariably such facilities have at least two layers of protective fencing and armed U.S. military personnel are on patrol--both inside and outside of the storage site.

2. Nuclear Weapons in Europe

The security of American nuclear weapons in Europe has received special attention in the last two or three years. This probably follows from the natural concern about the large number of weapons located there. Unclassified estimates indicate that approximately seven thousand American nuclear warheads are currently in Europe. This figure excludes any naval loadings. It is stated in unclassified sources, mainly The New York Times, that the bulk of such warheads are located in Great Britain, West Germany, and Italy.

The number of storage sites, and their location, naturally is a classified fact. But broadly speaking, a recent trend has been to consolidate these sites in order to facilitate their protection. However, the U.S. military has to be concerned with threats other than that posed by a sub-national group's attempt to steal or gain control of a weapon. Rather obviously, the foremost of these is the threat posed by the Soviet and Warsaw Pact military forces. The U.S. military must worry about any

attempted surprise attacks on NATO nuclear storage sites which could, in effect, decapitate the nuclear head of NATO. The pressure then is to increase the number of storage sites, which, of course, runs against that of consolidation. The trade-off is determined by military judgment exercised within political and diplomatic guidelines.

Theft and/or Control of a Nuclear Weapon

An important distinction exists between the theft and control of a nuclear weapon. Theft consists of the penetration of the storage facility and the physical removal of the weapon. Control could entail simply the physical penetration of a storage site without even an attempt at removal.

The distinction is far more than intellectual. Certain threat groups might be interested solely in gaining the attention of the mass media. A seemingly attractive method for this would be to take over an American nuclear-weapon storage site. For example, six to ten "eco-nuts" with a grudge against the nuclear electric power industry might desire to stage such a publicity event to draw attention to their cause.* "Success" would not require them actually to remove the nuclear weapon. The scenario would play out with a host of television cameras and spotlights trained on the storage site as long and complicated negotiations occurred between the authorities and those barricaded in the building containing the nuclear device. It is not difficult to envision the enormous publicity associated with such an event. And

*Within recent years radical groups have attacked nuclear power plants under construction in both Argentina and Brazil.

if such occurred in West Germany, additional strains undoubtedly would be introduced because of the political consequences of such an act.

The actual theft by a terrorist group of a nuclear weapon from its storage site could present far more ominous problems. A successful theft could be used as an element in a prolonged blackmail campaign against a government. While those "in the know" about the difficulty of detonating a stolen weapon might feel reassured because of various safing and arming systems and PAL devices, it is unlikely that such confidence could be transferred to the political authorities, the mass media, and the public. Should a weapon be stolen from a "secure" facility, it is more than likely that political leaders would lose confidence in their technical experts. At the least, a public informed that a terrorist group had stolen an A-bomb but told that the problem was minimal because of certain technical control devices of the particular model most probably would not have confidence that the problem was indeed minimal. Even if political leaders successfully are convinced that these technical characteristics would prevent detonation, they almost certainly will realize that the public will not be. This could induce political leaders to believe it necessary to capitulate to the terrorist demands.

Countermeasures

Various parties involved with these issues have been conducting studies and making plans in the past few years. Studies of this nature are, of course, classified. However, it appears that the distinction between theft and control has relevance for countermeasure design. It is absolutely imperative that alarms or other systems signal attack

of a nuclear-weapon storage site so that the physical removal of the weapon may be prevented. Other features of the storage site's design could assist this strategy. This should not be very difficult to accomplish and already seems to be the current situation.

Protection against unauthorized penetration is probably a great deal more difficult than preventing weapon removal. An assault group has the advantage of surprise for attacking a site of its own choosing. Probably more useful for a vulnerability assessment is the consideration of historical records of small unit surprise attacks on comparable facilities than the counting of guards or dollars programmed for security. One can think of the ease with which the Black September group penetrated the Munich Olympic compound in 1972, or that various domestic radicals of the late 1960s had in gaining access to police departments, the Pentagon, or the U.S. Capitol building. These facilities were supposed to be guarded, although admittedly not to the degree of a nuclear-weapon site in Europe.

Alternatively, instances of penetration of facilities designed to be even more protected than nuclear-weapon storage sites may be recalled. Otto Skorzeny's commando raid to free Mussolini from a mountain fortress involved an initial assault party of only ten to fifteen. Skorzeny's penetration of the very heavily guarded Hungarian presidential palace in 1945 is another case. There, an equally small party gained access to a building surrounded by protecting tanks and infantry.

An interesting fact appears to emerge from the study of such cases. It seems quite difficult for very small groups to succeed in penetrating

well-guarded secure facilities. Groups having only one to four members do not seem as capable as larger groups involving eight to twenty members. The squad of eight to twenty, if properly organized and capable of surprise, is a very serious threat. This conclusion is based on the common sense evaluation that such organizations have been successful in the past and that no reason for that pattern to change seems to have occurred. Such groups will probably always be a threat.

B. Security of Nth Country Nuclear Weapons

By the mid-1980s a second phase of proliferation could be underway. More importantly, in contrast to the first phase of proliferation--the acquisition of nuclear weapons by the great powers--this second phase would be characterized by the spread of nuclear weapons to less developed Third World countries whose domestic politics frequently involve high levels of military intervention and periodic military seizures of power. As indicated by the following table listing potential Nth countries and past instances of military intervention in each, nearly half of the most likely candidate nuclear-weapon states have experienced attempted or successful military coups d'etat in the past decade. Moreover, because their societal conditions are likely to remain conducive to intervention and the political aloofness of their military can be expected to continue to depend upon self-enforced disengagement rather than political neutrality grounded in acceptance of the principle of civilian supremacy, future instances of military seizures of power or displacement of one group of military rulers by another are likely to occur. Concomitantly, it is too soon to conclude that other potential Nth countries such as Egypt,

Table 17

MILITARY INTERVENTIONS IN POTENTIAL NTH COUNTRIES, 1958-1976*

ARGENTINA	1962(S),**1962(S), 1962(F), 1963(F), 1963(F), 1966(S), 1971(S), 1971(F), 1971(F), 1975(F), 1976(S)
BRAZIL	1961(S), 1964(S)
CHILE	1973(F), 1973(S)
EGYPT	
GREECE	1967(S), 1973(F)
INDIA	
INDONESIA	1960(F), 1965(S)
IRAN	
IRAQ	1958(S), 1959(F), 1963(S), 1963(F), 1963(F), 1963(S), 1964(F), 1965(F), 1966(F), 1966(F), 1968(S), 1969(F), 1971(S), 1973(F)
ISRAEL	
ITALY	
JAPAN	
LIBYA	1969(S), 1975(F)
NIGERIA	1966(S), 1966(S), 1975(S), 1976(F)
PAKISTAN	1958(S), 1969(S)
PHILIPPINES	
SAUDI ARABIA	
SOUTH AFRICA	
SOUTH KOREA	1961(S), 1962(F), 1963(F)
SPAIN	
SYRIA	1961(S), 1962(S), 1962(F), 1962(S), 1963(F), 1963(S), 1963(S), 1963(F), 1966(S), 1966(F), 1968(S), 1968(S), 1968(F), 1970(S), 1971(F)
TAIWAN	
TURKEY	1960(S), 1960(S), 1962(F), 1963(F), 1971(S)
VENEZUELA	1958(S), 1961(F), 1962(F), 1962(F), 1966(F)
WEST GERMANY	
ZAIRE	1961(S), 1965(S), 1966(F)

*BASED UPON GAVIN KENNEDY, THE MILITARY IN THE THIRD WORLD (NEW YORK: CHARLES SCRIBNER'S SONS, 1974), PP. 337-344.

**(S)=SUCCESS; (F)=FAILURE.

Iran, and South Korea which have not experienced a recent coup d'etat are no longer vulnerable to military intervention.

1. Pressures for Tight Control

The leaders of these coup-vulnerable Nth countries are likely to perceive preventing unauthorized seizure or use of nuclear weapons by a dissident domestic group, a military faction, or even a lone military man to be a high priority objective. Conventional military arguments for adequate command and control to assure that the nuclear force would not "go" without proper authorization would be strongly reinforced by fears of the potential domestic political consequences of unauthorized access to nuclear weapons.

Various control measures, with differing side-effects, could be adopted. These range from centralized storage of disassembled weapons, removed from their delivery vehicles and guarded by special troops, to reliance upon sophisticated electronic permissive action links (PAL). One cost of relying upon the less sophisticated control techniques would be decreased operational readiness. For instance, assuming centralized, off-site storage, time would be required to deliver the weapons to forward bases and then to mate-up the warheads with their delivery vehicles. Similarly, vulnerability to an opponent's first strike might increase significantly were certain control solutions, e.g., centralized warhead storage, adopted. Nonetheless, the leaders of these Nth countries could prefer initially to err on the side of more rather than less control.

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1 OF 2

2. Risk of Unauthorized Access

However, two qualifications are necessary, both of which suggest that many Nth country nuclear forces actually might provide opportunities for unauthorized seizure by sub-national groups. First, it might not be possible for some Nth countries to follow that initial preference for tight control. This would be the case for a politically unstable Nth country lacking advanced electronic PAL technologies and confronting either a hostile opponent for whom the problem of unauthorized seizure did not arise--e.g., Egypt (or one of the other Arab countries) vs. Israel or Pakistan vs. India--or an opponent that had solved its coup-vulnerability problem by acquiring more sophisticated PAL systems--e.g., Iraq vs. Iran. In each case, the cost in operational readiness of insuring control by measures such as centralized, off-site warhead storage might be deemed too high. That is, a combination of technical and political constraints might prevent some Nth countries from acting upon their initial preference for tight control.

Second, creation of a special troop contingent, or even a special police force, to guard the nuclear arsenal probably would encounter opposition from the existing armed forces, jealous of affronts to their corporate prerogatives. In some cases that opposition could prove insurmountable. Although the ensuing reliance upon the regular military in conjunction with other precautions could suffice to protect against unauthorized middle-rank initiatives, attempts by military coup-makers or internal dissident factions to suborn that military formation--or its leaders--or even to overwhelm it militarily would not be precluded.

Moreover, extrapolating from the frequent political unreliability or military ineffectiveness of Presidential Guards in coup-prone countries, even the existence of a special guard force would not rule out successful political or military measures to gain control of those weapons.

Thus, concern about possibly inadequate Nth country provisions for control against unauthorized seizure of nuclear weapons by a domestic dissident group, foreign commando-style terrorists, or a cabal of officers is warranted. That, too, has to be taken into account in assessing the prospects for access to nuclear weapons by sub-national groups should more widespread proliferation occur in the next decades.

IV. CONCLUSION

During the coming decades, a growing number of countries, as well as some non-governmental groups, could conclude that realization of their objectives required access to nuclear weapons. Two of the possible routes to nuclear weapons--purchase, barter, or joint production, and theft--have been examined in this report. That examination suggests that both the risk of nuclear black or gray marketeering and that of nuclear-weapon theft, particularly in the case of new nuclear-weapon states, has to be taken seriously.

Two of the specific points developed in the course of that analysis perhaps warrant reemphasis. First, future energy policy decisions should involve a careful weighing of the markedly adverse implications for the growth of nuclear black marketeering of widespread commercial dealings in reprocessed plutonium. Second, the emergence and growth of that spectrum of activities labeled nuclear gray marketeering would be a proliferation turning-point, eroding present and future efforts to reduce the likelihood of widespread nuclear proliferation. But, even though there exists growing concern about the dangers of black market nuclear transactions should a global "plutonium economy" emerge, the equally serious threat posed by nuclear gray marketeering remains insufficiently appreciated. One consequence of the preceding analysis, it is hoped, will be to change this state of affairs.

END