Terrorists' Acquisition of Nuclear Weapons: The Dangerous Synergy Between Weak States and Illicit Nuclear Procurement

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Preventing the spread of nuclear weapons to terrorists and additional states is a fundamental priority for national and international security, and anticipating how nuclear weapons could spread is vital to developing effective non-proliferation strategies. The war in Afghanistan against the Taliban highlighted a pathway to nuclear weapons that had been widely dismissed, namely terrorists using a weak or underdeveloped state as a base from which to develop a nuclear weapons capability. Such a strategy can allow terrorist groups to obtain nuclear weapons more quickly and with less chance of detection. With a base of operations, a terrorist group could develop a far deeper understanding of the many secret complexities of building a nuclear weapon and explore more consistently methods to obtain nuclear explosive materials. These advancements could be shared among terrorist groups and sympathizers with the common goal of acquiring a terrorist bomb.

Activities of al Qaeda in Afghanistan prior to the fall of the Taliban have demonstrated that a subnational group operating relatively freely within a weak state could develop a nuclear weapons program. According to the Commission on the Intelligence Capabilities of the United States Regarding Weapons of Mass Destruction, the intelligence community underestimated al Qaeda's fast-growing unconventional weapons capabilities and aggressive intentions.[1] Documents found and detainees interviewed after the fall of Kabul in 2001 demonstrated that al Qaeda had a "major biological effort" and had made "meaningful progress on its nuclear agenda."[2]

Al Qaeda was working far from the scrutiny of Western intelligence agencies or traditional non-proliferation institutions, such as the International Atomic Energy Agency (IAEA). Despite a UN embargo, al Qaeda was able to import dual-use equipment useful to a WMD program and obtain help from Pakistani nuclear scientists in putting together a nuclear weapons effort. An unanswered question is whether A.Q. Khan and his associates provided assistance to al Qaeda or intended to do so if the Taliban had remained in power. The failure to detect or stop al Qaeda's WMD efforts prior to the war highlights the inherent difficulty intelligence agencies face in penetrating certain types of security-conscious terrorist groups, and the progress terrorist groups can make on acquiring unconventional weapons capabilities in a weak, isolated state.

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[1] *Report to the President of the United States*, Commission on the Intelligence Capabilities of the United States Regarding Weapons of Mass Destruction, March 31, 2005, p. 273
[2] Ibid, p. 274

The Taliban government's demise also brought to light how terrorist groups can take advantage of illicit nuclear trade networks to achieve their goal of building nuclear weapons. Traditionally, illicit nuclear trade has been conducted by insiders, businessmen, or nations with little desire to outfit terrorists with nuclear weapons capabilities, despite their willingness to break the laws of many nations in their quest to help another state's program. As a result, terrorist groups or their agents have been forced to depend on criminal networks that offer little access to the kinds of items actually needed in a nuclear weapons program.

Most of the known transactions have been scams or have involved minute quantities of nuclear material. However, a terrorist group ensconced in a weak, supportive state could create an illicit procurement organization with a full array of false end users and "respectable" buyers, poised to tap into networks of illicit traders and suppliers able to provide key items for a nuclear weapons program. In theory, such a terrorist group could develop more sophisticated nuclear weapons and perhaps in the future have a chance to develop capabilities to make fissile material.

Documents Found in Afghanistan

The U.S. government has publicly released few documents found in Afghanistan; thus, detailed reports about al Qaeda's nuclear weapons efforts remain unpublished. However, after the fall of the Taliban in Afghanistan, the media was aggressive in gathering documents about al Qaeda's quest for nuclear weapons and other weapons of mass destruction. CNN producers and correspondents were especially active in jumping fences, exploring caves, and entering buildings searching for documents. ISIS collaborated with CNN in that effort, translating and analyzing many documents written in Arabic.

In a house in an upscale Kabul neighborhood purportedly occupied by members of al Qaeda, CNN found one cache of documents on making explosives and a 25-page handwritten document in Arabic titled "Superbomb." An elementary primer on nuclear weapons, the text provides a broad and fragmented introduction to making nuclear weapons. The primer is missing its first page, and the rest of the text gives no hint of the author or intended audience. The extent of the author's expertise is difficult to discern, exhibiting an understanding of basic nuclear physics and chemistry but lacking in familiarity with nuclear weapons' design and manufacture. For example, the author states that anyone desiring to obtain a nuclear weapon must set up a plant for enriching uranium, and describes laser enrichment as a "simple" method to pursue. The text presents several properties of plutonium and uranium but does not discuss the production of weapon components out of these materials.

Moreover, the text is simplistic and has errors. For instance, a hand-drawn diagram of a nuclear explosive appears unworkable. This schematic is difficult to interpret, because accurate schematics of fission weapons are easy to obtain. The device is inside a hard metal casing and involves two 4-kilogram blocks of fissile material with a 10-kilogram charge of TNT behind

each block. According to the text surrounding the schematic, the device works by igniting the TNT and propelling the pieces of fissile material together.[3]
The text has a few marginal notes. These notes could have been written to draw attention to the sections explaining nuclear weapons for either a reader or someone who used the text as a basis to lecture students. A question mark in a different handwriting than the text was placed after the section head “An Explanation of Nuclear Weapons,” perhaps by someone casting aspersions on what was written in that section.

ISIS also obtained a document from British media that symbolizes the confused state of many of the public reports on al Qaeda’s nuclear weapons capabilities. The document was a torn, partial page printed from a website and found at an al Qaeda safe house in Kabul. The media reported in late 2001 that the page indicated that al Qaeda was interested in nuclear weapons, even thermonuclear weapons. In fact, the page was from a bizarre website that did mention nuclear weapons but also the phony elements Jupiternium, Saturium, and Marisum. When people noticed these obvious mistakes, the media was soundly rebuked and belittled for hyping al Qaeda’s capabilities. However, on an edge of the document underneath the fake elements was written in Arabic the word “bullshit.” The Arabic reader appears to have realized that this information was useless.

CNN found another cache of documents in an office off the dreary lobby of Kabul’s Intercontinental Hotel. The documents involved the plans of UTN, an organization run by Pakistani nuclear scientist Sultan Bashir Mahmood, a key former member of Pakistan’s nuclear program and a strong supporter of the Taliban. In 2001, Mahmood met with Osama Bin Laden and his associates and reportedly had long discussions about chemical, biological, and nuclear weapons.[4] These documents outlined the ambitious plans of UTN to reconstruct Afghanistan. Mahmood wanted to forge partnerships with other companies to create banks and a wide variety of industries. UTN planned to develop the mining of a range of minerals, including uranium. It was also planning to fund several of its activities with funds from the Pakistani government.[5]

UTN was dependent on the Taliban regime and indirectly on al Qaeda for the success of its projects, many of which involved significant sums of funds and potentially large profits for its investors. At a minimum, the Taliban regime and al Qaeda had tremendous bargaining power over UTN scientists to garner their assistance. UTN's growing dependence on the Taliban regime would have made it increasingly difficult for Mahmood and his associates to say no to Taliban and al Qaeda requests. Given Mahmood’s fundamentalist, pro-Taliban views, he may have been inclined to help in any case.

The involvement of Mahmood and other Pakistani scientists could have provided the spark to ignite al Qaeda’s successful effort to build nuclear weapons. UTN officials contributed to the

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[3] Student notebooks found by CNN also have nuclear devices represented in a similar way. In this case, students were apparently taking notes during lectures where the nuclear explosive device involved two 4-kilogram blocks of highly enriched uranium, separated by about 35 centimeters, that would be fired toward each other by the detonation of TNT.

[4] David Albright and Holly Higgins, *Pakistani Nuclear Scientists: How Much Nuclear Assistance to Al Qaeda?* August 30, 2002, http://www.exportcontrols.org/pakscientists.html.

[5] *Pakistani Nuclear Scientists: How Much Nuclear Assistance to Al Qaeda?*, op cit.

Taliban regime's extensive experience in supervising large, complicated projects. UTN scientists could have provided experienced program management for a nuclear weapons project, leveraging multiple contacts within the Pakistani nuclear community. As a result, they were well positioned to make significant contributions to an al Qaeda nuclear weapons program.
Overall, the documents found in Afghanistan imply that al Qaeda's effort to acquire nuclear weapons was in its early stages, although its effort was serious in nature and likely accelerating. Based on the experiences of developing countries that have sought nuclear weapons, the leadership of al Qaeda had made the important realization that it needed to acquire competent help if it were to succeed in acquiring nuclear weapons. By 2001 al Qaeda had made important progress on that goal and could count on the help of several important Pakistanis.

What If?

Al Qaeda was well positioned to make advances in its nuclear weapons program. Whether it would have succeeded, particularly in acquiring sufficient nuclear explosive material, is subject to debate. Al Qaeda's operations in Afghanistan offered it many advantages, among them the following:

- The Taliban government tolerated and in some cases supported al Qaeda's efforts to seek WMD. The government conferred legitimacy on al Qaeda and shielded it from outside pressure and scrutiny.
- Al Qaeda was creating bases of operation that would have allowed it to conduct secret, long-term research and development work on nuclear weapons. It could create a complex to make and test nuclear weapon components.
- Al Qaeda could recruit key scientific and engineering personnel from abroad, including Pakistani nuclear scientists willing to help.
- Al Qaeda experts could organize a concerted, long-term effort to acquire fissile material for nuclear weapons from the former Soviet Union or even Europe.
- Al Qaeda could create an illicit procurement system to import nuclear dual-use items for its nuclear weapons program under the cover of civil industries, medical facilities, and universities. Its agents posing as legitimate buyers could connect with suppliers and transnational illicit procurement networks unlikely to sell overtly to terrorists.
- The Pakistani government may have continued to shield the Taliban and indirectly assist al Qaeda's efforts to obtain WMD. UTN may have received Pakistani government funding for its industrial projects which could have contributed to al Qaeda's efforts.
- Al Qaeda could have purchased atomic bomb designs or bomb components from the Khan network. This network may also have assisted al Qaeda's efforts by providing a wide range of technical assistance and perhaps later even gas centrifuges.

The Afghanistan experience shows that terrorists can work in a weak non-industrialized state to develop nuclear weapons capability. Al Qaeda and other terrorist groups remain determined to get nuclear weapons; may possess the patience to implement a long-term strategy to acquire the necessary expertise, capabilities, and materials; and may prefer weak or failed states as locations to gain necessary experience and overcome bottlenecks. Terrorist groups may pursue a strategy over many years to acquire the capability to make nuclear weapons, with some similarities to the strategies pursued by developing countries to obtain nuclear weapons.

Proliferation Pathways

Nuclear proliferation pathways entail the set of steps and methods used by an organization to acquire nuclear weapons. The most basic pathway requires methods and means. The technical method to acquire fissile material and manufacture a nuclear weapon involves the production and separation of plutonium or the enrichment of uranium. Acquisition may also include the theft or purchase of a functional nuclear weapon or sufficient nuclear weapons material to make a nuclear weapon. Technical capability can be accomplished with indigenous industries and scientific capabilities, or through theft, illicit procurement of subcomponents, and global networks offering items for sale, with terrorist groups highly dependent on the latter.
There are many pathways to nuclear weapons. The pathways pursued by states are well known. The pathways available to terrorists are less developed and subject to more debate about their nature and chance of happening. Table 1 lists several pathways commonly discussed that terrorists may pursue. This section addresses: (1) the acquisition of nuclear explosive material and construction of a nuclear weapon and (2) the production of nuclear explosive material and construction of a nuclear weapon.

The probability of either occurring is not discussed; both appear to have a low probability, with internal production less probable than acquisition from an external source. Given the consequences of the detonation of a nuclear weapon, neither possibility can be ignored. Prevention of direct acquisition requires extensive, on-going governmental, non-governmental, and private efforts; indicators of and countermeasures to production need to be factored into threat assessments and long-term planning respectively.

Accepting that nuclear weapons are difficult to make, the pathways envisioned are more complex than often believed and may depend on extensive preparatory work. In these efforts, the role of illicit nuclear procurement is more critical. Further, this approach assumes that terrorists will develop nuclear weapons suited to their goals and capabilities. These weapons could look very different from those developed by states.

Role of Illicit Procurement

For the last three decades, developing states sought the capabilities to produce fissile material through illicit procurement abroad or from transnational networks. Pakistan, Iran, Iraq, India, and North Korea have all depended extensively on illicit, overseas procurements for their nuclear weapons programs. Terrorists are likewise expected to procure a range of items for their nuclear weapons programs and will likely move to the same types of methods used by states to obtain such items illicitly.

The A.Q. Khan network was the most advanced and ambitious of transnational networks. Begun as a way to supply Pakistan's nuclear weapons program, the network grew into a supplier to Iran, North Korea, Libya, and perhaps others. Similar networks may already exist or may emerge in the coming years. A key characteristic of the Khan network was its ability to provide one-stop shopping for a nuclear weapons program, using an array of suppliers and manufacturers and extensive knowledge about gas centrifuges and nuclear weapons.
Khan's success can be traced to his creation of international manufacturing and smuggling operations, always seeking businessmen eager to make money and countries with weak export controls. For example, the Khan network organized the acquisition of machine tools in Europe and their shipment to Malaysia for use in making centrifuge components, which were exported to Dubai and then to Libya. Agents of the Khan network arranged for a centrifuge subcomponent to be made by an unsuspecting company in Switzerland using raw materials from Russia or Italy that had been ordered by a trading company in Singapore. The agents then arranged for the subcomponent to be sent to Turkey where another key player in the Khan network integrated it with other parts into a centrifuge part that was sent first to Dubai and then Libya.

The continuous improvement and global spread of technology eases the procurement of nuclear weapons materials, equipment and know-how. More countries, many of which are still considered developing nations, have sophisticated manufacturing and machine tool capabilities that can be exploited to make items for nuclear weapons. In addition, detailed classified information about nuclear weapons and how to make them continues to leak. Very detailed information has spread to shady entrepreneurs determined to make a profit. Experts with experience in producing fissile material and nuclear weapons are now spread throughout the world, potentially providing a pool of expertise for terrorist efforts to build nuclear weapons. New technologies could also emerge that would simplify the task of making fissile material or producing nuclear weapons.

Pathway: Terrorist Procurement of Fissile Material and Construction of a Weapon

Many experts have judged terrorists capable of making a crude fission weapon, if they acquired sufficient fissile material through theft or purchase and obtained the necessary expertise to build the weapon itself. Figure 1 shows a schematic of the pathway involving a terrorist group acquiring a nuclear weapon by stealing or buying fissile material from a national stock and then manufacturing the weapon.

The world is well stocked with weapons-usable nuclear explosive material. The continued accumulation of stocks of nuclear explosive materials will pose a security threat for decades. Table 2 lists estimated national inventories of both separated and unseparated plutonium and highly enriched uranium as of the end of 2003. Table 3 provides a snapshot of separated plutonium and highly enriched uranium stocks at the end of 2003 and their ranking as to their relative vulnerability.

In the future, the separation of additional types of nuclear explosive materials, in particular neptunium and americium, could add to concerns over the possible use of fissile materials in terrorist nuclear weapons. Nonetheless, stealing any of this material remains challenging, particularly as the risk of theft of fissile material is further reduced through better physical protection and accounting measures combined with consolidation and elimination strategies.

Accomplishing many of the tasks necessary to build the weapon itself could be easier in weak states. This pathway could be played out across many countries. The material could be stolen from one facility, converted into metal components in a facility in another country, assembled with other components into a nuclear weapon in yet a third country, and smuggled into a fourth country and detonated. Failed or weak states may be unwitting locations for key tasks.

Operating in a failed or weak state is not without risk. A failed state may not be a practical choice to carry out industrial or sophisticated engineering activities, and may be too dangerous for even a terrorist group to conduct such activities unhindered. In a weak state, the terrorist group would need to worry that the host government would turn against it and tip off other governments or take over the program itself, perhaps gaining access to the bomb. To protect its operations, the terrorist group would aim to keep its activities as secret as possible and perhaps make use of back-up or parallel locations beyond the given state's purview.

In general, an effort to make a nuclear weapon requires a range of efforts, including:

- theoretical calculations and computer codes;
- acquisition and preparation of high explosives or propellants;
- experiments in preparing and using propellants or high explosives in the nuclear weapon;
- preparation and possible purification of metallic uranium or plutonium, including melting and casting of metals and quality control of these activities;
- obtaining or manufacturing necessary electronics, including items to produce and supply energy, arming and fusing systems, and rudimentary safety systems or procedures;
- possibly developing, testing, and manufacturing neutron initiators; and
- testing of subsystems or mock-ups of a nuclear weapon or device.

Accomplishing these tasks would be expected to require a range of small-scale nuclear weaponization facilities, including:

- nuclear and non-nuclear component manufacturing sites;
- propellant or high explosive test facilities or sites; and
- nuclear weapon assembly facility.

All these activities can be accomplished in small facilities with several tens of skilled individuals. An isolated location could be necessary for testing components. Terrorist groups would be expected to try to find as many short cuts as possible. As mentioned above, acquiring assistance would be expected to be a priority.

Terrorist groups may establish very different requirements for the explosive yield, reliability, safety, and security of a nuclear weapon; in the process, they may greatly simplify the development and manufacture of a nuclear weapon. A terrorist group may be satisfied with a design that a state would consider a total failure. It may seek an explosive yield only on order of a hundred tonnes, enough to level one or more city blocks and kill tens of thousands of people.

Gun-type explosive design

Most experts have judged al Qaeda and other terrorist groups capable of building a gun-type nuclear weapon. However, Carson Mark, a member of the Manhattan Project and leader of the Theoretical Division at Los Alamos National Laboratory from 1947 until 1973, told me often in the 1980s that building a gun-type device posed several engineering challenges. These challenges can complicate a terrorist effort.

A crude gun-type weapon uses about 50 kilograms of weapon-grade uranium (highly enriched uranium enriched to 90 percent or greater in the isotope uranium 235), or a similar amount of neptunium, and uses a propellant to fire one portion of this dense material at the other down an artillery barrel. When the masses combine, the total amount of weapon-grade uranium is supercritical. A neutron from a neutron initiator or from the background would start the chain reaction, leading to an explosion.

The biggest drawback of a gun-type design, however, is the large amount of weapon-grade uranium needed. Although such stocks are large worldwide, relatively few places have large enough stocks for a gun-type weapon, although multiple thefts remain a possibility. Highly enriched uranium is concentrated in nuclear weapon states with extensive and growing security, making the theft or diversion of enough material difficult. Separated neptunium is almost exclusively found in nuclear weapon states and exists in relatively small amounts.

One specialized component that is difficult to make is a neutron initiator, which provides neutrons when the masses of highly enriched uranium are assembled, starting the chain reaction. A rudimentary initiator could be made from beryllium and polonium 210, a radioactive material with a relatively short half-life. The recent poisoning of Alexander Litvinenko in Britain with polonium 210 raises questions about the possibility of terrorists acquiring this material, where on order of a milligram is enough for a neutron initiator. Alternatively, the construction of an initiator can be avoided by acquiring a specialized neutron gun found in the oil industry.

Terrorists may seek to avoid the use of a neutron initiator completely, and instead use background neutrons to start the chain reaction. Such a design is straightforward, although the design requires some careful work to ensure that the highly enriched uranium remains in one piece long enough after being assembled for a stray neutron to start the chain reaction.

Some infrastructure would be necessary to make and test components of the gun-type device and to conduct final assembly. A simple structure would likely be constructed to test fire heavy surrogate projectiles down an artillery barrel. Similarly, equipment to fashion highly enriched uranium metal components would be required. These facilities can be small and easily hidden, but acquiring the necessary equipment may take some time and pose challenges.

Implosion-type explosive design

An alternative is to use an implosion design, where the nuclear core is compressed uniformly by high explosives. This design is considered in general to be harder to make than a gun-type design, but one important advantage is that it requires one-third to one-half the amount of weapon-grade uranium or neptunium in a gun-type device. In addition, separated plutonium can be used, a material which is more widespread than highly enriched uranium and found in large quantities in both civil and military programs. Civil separated or unirradiated plutonium is also transported far more frequently and in much larger quantities than highly enriched uranium.

Some experts are skeptical that terrorist groups such as al Qaeda could build an implosion-type nuclear weapon. Information discovered by CNN in Afghanistan about al Qaeda's interest in nuclear weapons lent support to that view. For example, no schematics of an implosion system were found in Afghanistan. Although CNN found and ISIS translated many documents on testing and making explosives, none were found that discussed shaped charges, necessary for an implosion system. Nevertheless, al Qaeda or other terrorist groups may have implosion designs unknown to us, or they may acquire such designs. The Khan network sold an implosion design and manufacturing and assembly instructions to Libya and offered them to Iraq. One of the most damaging legacies of the Khan network is that complete, detailed nuclear weapon designs and manufacturing manuals may now be in illicit nuclear commerce.

In any case, a terrorist group would have a harder time mastering an implosion system. It could be expected to try to simplify the design to ease its manufacture. For example, it could avoid a neutron initiator by using reactor-grade plutonium, particularly if the yield is accepted to be less than one kiloton. Mastering all the steps might require a secure base of operations for an extended period of time. Operating in a weak state could provide needed isolation and security to develop expertise and experience in manufacturing certain specialized components. Even with a design in-hand, a group may need to test the high explosive components and this testing program may be time consuming. A terrorist group would need to create some infrastructure to make, test, and assemble the parts of an implosion system. Final assembly of the device would also require special care. A range of equipment and materials would need to be procured successfully.

Possible Pathways for Terrorists Based in Weak States

Terrorists have generally been viewed as unable to put together the facilities to separate plutonium or enrich uranium. Yet, two pathways could become accessible to terrorist groups: acquiring a small gas centrifuge plant, or building a crude reprocessing plant with the goal of obtaining enough fissile material for at least one nuclear weapon. To succeed in either pathway, the terrorist group would require considerable expertise, a large amount of funds, and a safe haven for several years. If the Taliban had remained in power, al Qaeda with sufficient assistance from Pakistanis could have eventually moved toward making fissile material itself. Any such effort would likely become more national in character as it developed. In this case, a terrorist group could become the catalyst for a weak state to acquire a nuclear weapon.

Pathway: Procuring a small gas centrifuge plant and uranium hexafluoride

The Khan network has raised the specter of a transnational entity selling a small “turnkey” gas centrifuge plant and nuclear weapons designs to terrorist groups. Such a sale would be expected to occur only under very special conditions. But as Afghanistan has shown, surprises can occur. In addition, if a terrorist group managed to buy and operate only a relatively few centrifuges and produced enriched uranium, perhaps not even highly enriched uranium, it could use this material as part of a bluff. It would dramatically bolster its image and cause a great deal of panic.

Under this pathway, any centrifuge plant would be expected to be significantly smaller than a plant ordered or built by developing states seeking nuclear weapons. Libya’s order from Khan was for 10,000 P2 centrifuges, which were based on a German designed centrifuge called G2 and deployed by Urenco in the early to mid-1970s. A plant with 1,000 P2 centrifuges utilizing maraging steel rotors could make enough highly enriched uranium for a crude implosion weapon within a year, and enough for a crude gun-type weapon within about two years.

With larger numbers or more powerful centrifuges, these times would be reduced proportionally. In the future, if more powerful centrifuges could be ordered by terrorist groups, far fewer centrifuges would be needed. For example, Iraq obtained the design for a 3-meter long, carbon-fiber Urenco machine prior to the 1991 Persian Gulf War. Instead of 1,000 centrifuges, roughly 200 of these more powerful centrifuges would be needed to have the same output of highly enriched uranium.
Figure 2 describes a theoretical pathway based on the activities of the Khan network that illustrates the steps that must be accomplished. Succeeding in such a feat would still require a terrorist group to have considerable expertise and resources to operate the facility. Even if it was buying a turn-key facility and sufficient uranium hexafluoride feed gas, it would still need tens of experts and dozens of support personnel. If the terrorist group had to organize the project, acquire the items on its own, and build the plant and produce the uranium hexafluoride, it would require on order of 100 experts in various fields supported by several hundred more. Finding that number of experts would be expected to be too challenging for a terrorist group, even if it were based securely in a weak state.

Pathway: Building a low-technology reprocessing plant and acquiring spent fuel

A terrorist group may succeed in building a crude reprocessing plant, although it would need to also acquire spent fuel containing plutonium or highly enriched uranium. Several studies at US national laboratories have demonstrated the steps a country would need to take to build a small reprocessing facility able to separate about 10 kilograms of plutonium from spent fuel produced in light water reactors. The underlying technology was declassified many years ago, and the required equipment is commonly available or could be imported. Nonetheless, a terrorist group would still need considerable expertise to build and operate such a plant, but the number of required personnel is likely significantly less than needed for a turn-key centrifuge plant.

A 1977 Oak Ridge National Laboratory study titled "Simple, Quick Processing Plant" listed a set of criteria necessary for a state to build such a plant. An evaluation of the criteria, such as cost, equipment, or numbers of necessary personnel, would not preclude a sophisticated terrorist group from building such a plant, if the group was located in a state friendly to or at least not committed to stopping or exposing the group's endeavors. The terrorist group would still need to acquire enough spent fuel. Spent fuel could be located in or near weak or failed states, and this material may be significantly easier to acquire than separated plutonium or highly enriched uranium. Nonetheless, this pathway is expected to remain very difficult.

Conclusion

Determining the conditions needed for a subnational entity to build a nuclear weapon remains difficult. Acquiring sufficient nuclear explosive material will remain a daunting challenge, wherever the terrorist group operates. Operating in a weak state can ease the terrorists' task of building a nuclear weapon. With a base of operations, a group could master the construction of crude fission weapons, including implosion-type weapons. A base would also allow a terrorist group to test conceptually and experimentally components or mock-ups of particular weapon designs. Experts could explore designs more suitable to the terrorists' goals and capabilities. A secure base would also facilitate assemblage of individual components and their final assembly into a nuclear device.

The production of separated plutonium or enriched uranium by a terrorist group appears possible only under special conditions in a weak state. Al Qaeda in Afghanistan under the Taliban may have met such conditions, although al Qaeda was years away from being able to realize such a plan. However, terrorist groups may seek centrifuge designs and other classified information from illicit procurement networks. They may intend to eventually build such a plant, or they may try to sell or barter this information to other groups or states.

There is a need for a deeper discussion of how terrorists may obtain nuclear weapons. A focus should be how such efforts are made easier or more likely by terrorists operating in weak or failed states, where export controls, intelligence, public opinion, and international inspections are much less effective in thwarting proliferation by subnational groups.

Figure 1 A Key Pathway: Terrorist Construction of a Nuclear Weapon Using Procured Weapon-Usable Fissile Material

Institute for Science and International Security (ISIS)

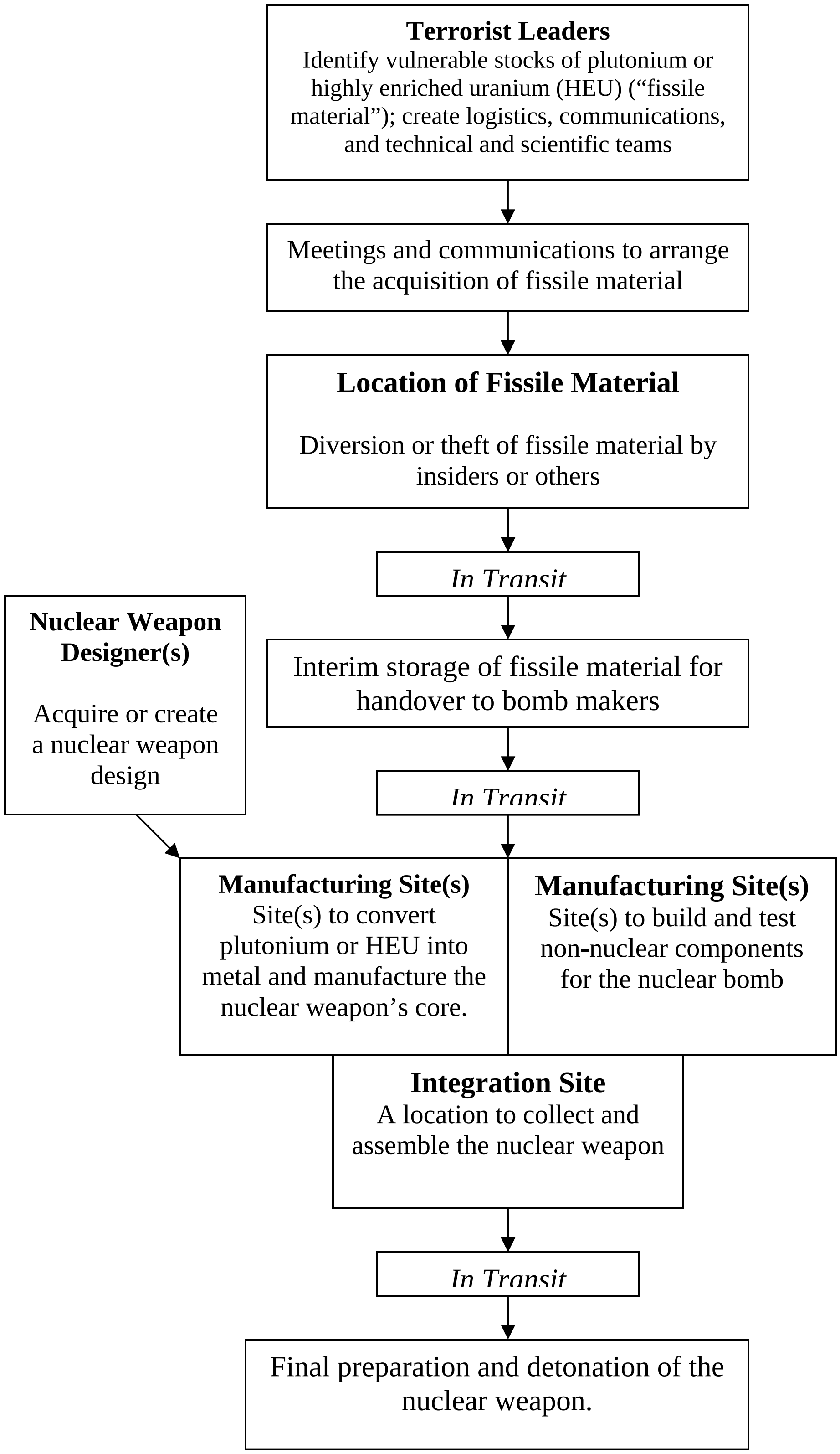

Figure 2 A Simplified Khan Network Pathway: Based on Libya's Order of a Gas Centrifuge Plant
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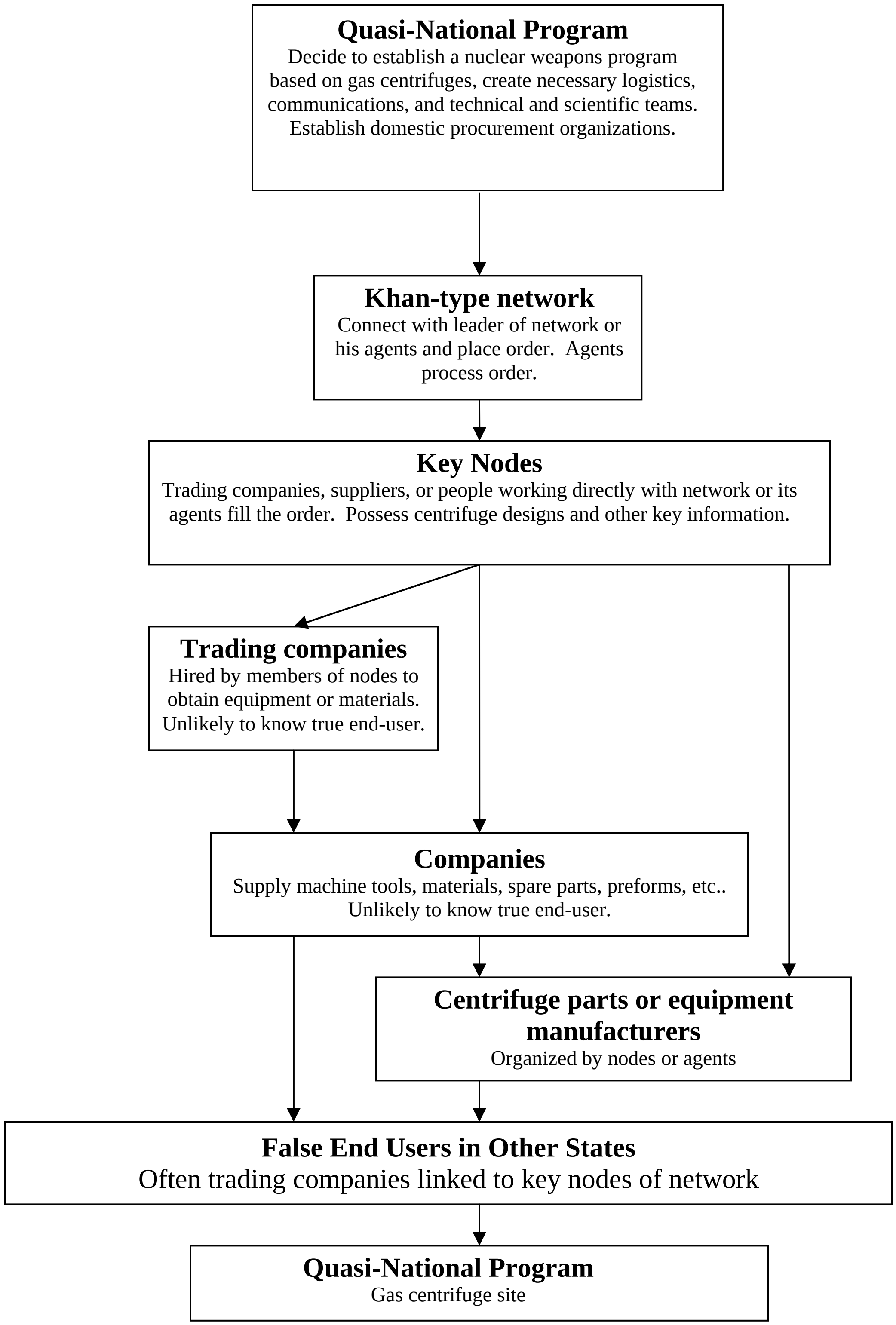

Table 1 Major Pathways to Nuclear Weapons by Terrorists

Pathway	Major Hurdles
Steal or purchase a functioning nuclear weapon	Limited supply, high security over weapons
A state provides a nuclear weapon to terrorists (state sponsored terrorism)	Lending state risks nuclear retaliation, supply limited, but possible
Acquire a nuclear weapon when a state collapses	Supply limited, but possible
Obtain nuclear explosive material and build a crude fission weapon	Large supplies of material and necessary equipment; Challenging to obtain fissile material and make weapon
Produce nuclear explosive material and make weapon	Future scenario; difficult to do in any case

Table 2 Key Nuclear Explosive Material Holdings by Country, end 2003, in tonnes

Country	Plutonium	HEU	Np 237	Am	Total (rounded)
Argentina	11	0.020	0.066	0.198	11.3
Armenia	1.4	0	0.097	0.209	1.7
Australia	0	0.35	0	0	0.35
Austria	0	0.005-0.02	0	0	0.005-0.02
Belarus	0	0.25-0.37	0	0	0.25-0.37
Belgium	23.5-24.5	0.70-0.75	1.28	1.742	27.2-28.3
Brazil	2.1	0-0.001	0.060	0.058	2.22
Bulgaria	8.5	0.006	0.595	0.852	9.95
Canada	135	1.35	0.807	2.330	139
Chile	0	0.005	0	0	0.005
China	9.1	22	0.156	0.119	31.5
Colombia	0	0	0	0	0
Denmark	0	0	0	0	0
Czech Republic	6.2	0.08-0.14	0.291	0.362	6.93-6.99
Finland	11	0	0.517	0.839	12.4
France	236.1	33-34.3	9.80	12.9	292-293
Georgia	0	0-0.001	0	0	0-0.001
Germany	93-96	1.4-2.7	4.87	7.67	107-111
Ghana	0	0.001	0	0	0.001
Greece	0	0.003-0.016	0	0	0.003-0.016
Hungary	7.5	0.15-0.25	0.289	0.429	8.37-8.47
India	13.9-14.9	0.005-0.01	0.142	0.290	14.3-15.3
Iran	0	0.007	0	0	0.007
Israel	0.56	0.034	0	0	0.594
Italy	6.5	0.10-0.20	0.096	0.355	7.1-7.2
Jamaica	0	0.001	0	0	0.001
Japan	151.6-153.6	2.0	5.12	8.87	168-170
Kazakhstan	3.0	10.59-10.94	0	0	13.6-13.9
Latvia	0	0.020-0.025	0	0	0.02-0.025
Libya	0	0.025	0	0	0.025
Lithuania	10	0	0.220	0.342	10.6
Mexico	2.4	0.012	0.076	0.095	2.58
Netherlands	3-3.9	0.73-0.81	0.147	0.249	4.13-5.11
Nigeria	0	0.001	0	0	0.001
North Korea	0.04	0.042	0	0	0.077-0.087
Norway	0	0.004	0	0	0.004
Pakistan	0.84	1.1	0.008	0.019	2.0
Philippines	0	0	0	0	0
Poland	0	0.49	0	0	0.49
Portugal	0	0.007-0.008	0	0	0.007-0.008
Romania	2.4	0.033-0.044	0.012	0.019	2.46-2.48
Russia	271.2	1088-1103	3.47	5.313	1370-1380
Serbia	0	0.013	0	0	0.013

Country	Plutonium	HEU	Np 237	Am	Total (rounded)
Slovakia	8.4	0	0.390	0.561	9.35
Slovenia	2.7	0-0.005	0.132	0.157	2.99
South Africa	5.8	0.61-0.76	0.274	0.308	6.99-7.14
South Korea	44	0.002	1.54	1.851	47.4
Spain	26.9	0	1.13	1.843	29.9
Sweden	41.8	0.002	1.17	3.086	46.1
Switzerland	17.5-20	0.005-0.010	0.859	1.256	19.6-22.1
Syria	0	0.001	0	0	0.001
Taiwan	22	0.003-0.010	0.648	1.511	24.2
Thailand	0	0	0	0	0
Turkey	0	0.008	0	0	0.008
Ukraine	41	0.16-0.25	2.34	2.608	46.1-46.2
United Kingdom	96.3-102.4	23.4	1.01	3.81	125-131
United States	507.5	705	16.5	27.12	1260
Uzbekistan	0	0.12	0	0	0.12
Vietnam	0	0.0056	0	0	0.0056
15 Others	0	0-0.001	0	0	0
Totals	**1835**	**1900**	**54**	**87**	**3875 (rounded)**

Source: ISIS, www.isis-online.org

Table 2: Fissile Materials of Special Concern: In-Country Stocks of Separated Plutonium and Total Stocks of HEU (end 2003, in tonnes)*

Country	Separated Plutonium			HEU			Total[a]
	Military	Civil	Subtotal[a]	Military	Civil	Subtotal[a]	
Russia	95	88[b]	183	1070[c]	15-30	1085-1100	**1275**
Pakistan	0.04	--	0.04	1.1	0.017[d]	1.120	**1.16**
North Korea	0.015-0.04	--	0.015-0.04	?	0.042	0.042	**0.06-0.08**
India	0.4	~1-1.5	1.4-1.9	~0.5	0.005-0.01	0.505-0.51	**1.9-2.4**
China	4.8	--	4.8	20	1	21	**26**
Countries with Russian-supplied HEU[f]	--	?[e]	?	--	1.36-1.74	1.4-1.7	**1.4-1.7**
Kazakhstan	--	3.0	3.0	--	10.59-10.94[g]	10.6-10.9	**14**
South Africa	--	--	0	--	0.61-0.76	0.61-0.76	**0.61-0.76**
Belgium	--	3.5	3.5	--	0.5	0.5	**4.0**
Canada	--	--	0	--	1.35	1.35	**1.35**
France	5	78.6	84	29	6.4	35.4	**119**
Germany	--	12.5	12.5	--	1	1	**13.5**
Israel	0.6	--	0.6	?	0.034	0.034	**0.6**
Japan	--	5.4	5.4	--	2.0	2	**7.4**
Netherlands	--	--	0	--	0.73-0.81	0.73-0.81	**0.73-0.81**
Switzerland	--	0.5-1.0	0.5-1.0	--	0.005-0.01	0.005-0.01	**0.5-1.0**
United Kingdom	3.2	96.2	99	21.9	1.5	23	**123**
United States	47	45[h]	92	575	125[i]	700	**792**
Smaller Stocks of HEU in Many Countries	--	--	0	--	0.57-0.73[j]	0.6-0.7	**0.6-0.7**
Smaller Stocks of Plutonium in Several Countries	--	<1	<1	--	--	0	**<1**
Total[a]	**155**	**335**	**490**	**1720**	**175**	**1895**	**2400**

Note

Plutonium and highly enriched uranium (HEU) are both key ingredients in nuclear weapons, making them two of the most dangerous materials in existence. Table 2 estimates stocks of separated plutonium and both separated and irradiated HEU in countries that are of special concern because of the risk of diversion for use by terrorists. Separated plutonium and HEU are directly usable in nuclear weapons. Much of the irradiated HEU stock is not very radioactive and is relatively easy to transport. Irradiated plutonium unseparated from power reactor spent fuel, while still posing a proliferation risk, is more difficult for terrorists to convert into a nuclear weapon, and is not included in the estimates. The order of the countries in Table 1 is meant to suggest which stocks are most important to understand and secure, but this judgment is subjective. The estimates in this table represent the amount of such stocks held in a country, rather than the amount owned by that country. Countries with active reprocessing programs, most notably France and the United Kingdom, may hold a significant amount of foreign-owned separated plutonium at their reprocessing facilities. Table 1 also includes countries, such as France, the United Kingdom and the United States, with significant quantities of separated plutonium and HEU that have implemented security measures that meet or exceed international standards. Despite these measures, theft of the material remains a possibility, making these large stocks a concern in the effort to prevent terrorist access to nuclear weapon materials.

Sources

The information presented in this table is drawn from the following ISIS reports:
Status and Stocks of Military Plutonium in the Acknowledged Nuclear Weapon States, June 2005.
Separated Civil Plutonium Inventories: Current Status and Future Directions, by David Albright and Kimberly Kramer, June 2005.
Military and Excess Stocks of Highly Enriched Uranium (HEU) in the Acknowledged Nuclear Weapon States, June 2005.
Civil HEU Watch, by David Albright and Kimberly Kramer, June 2005.
ISIS Estimates of Unirradiated Fissile Material in De Facto Nuclear Weapon States, Produced in Nuclear Weapons Programs, June 2005.

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[a] Rounded.

[b] This value includes about 50 tonnes of plutonium that Russia has declared excess to military needs and committed to peaceful uses.

[c] Russia has committed to blend down 500 tonnes of HEU to LEU. By the end of 2003, it had blended down 200 tonnes. The remaining 300 tonnes remain in its military stock, probably in nuclear weapons, and not isolated from its primary military stock and committed to peaceful uses. As a result, this stock is assigned to the military stock. The United States has also declared a large amount of military HEU excess to military needs but has isolated this HEU from its primary military stock and committed it to peaceful uses. For this reason, remaining US excess HEU is included in the civil HEU category (see footnote (i)).

[d] The civil HEU value for Pakistan includes 16 kg of US-origin HEU and 1 kg of Chinese-origin HEU.

[e] Believed to be small, but not estimated.

[f] Includes former Soviet States (Belarus, Georgia, Latvia, Ukraine, Uzbekistan) and other countries with Russian-supplied research reactors (Bulgaria, Czech Republic, Hungary, Libya, Poland, Serbia, Vietnam). Kazakhstan, China, Germany, North Korea also have in-country stocks of Russian-supplied HEU, but are listed separately in this table. An estimated 0-5 kg of 36% enriched Russian-origin spent fuel may also have remained in Romania.

[g] The value for Kazakhstan includes 10.5-10.8 tonnes of Russian-origin HEU used in the BN-350 breeder reactor and 0.09-0.14 tonnes Russian-origin HEU for research and development activities.

[h] Plutonium declared excess to military needs and committed to peaceful uses. This value does not include about 7.5 tonnes of declared excess plutonium contained in irradiated material.

[i] The civil HEU value for the United States includes the remaining 123 tonnes of HEU declared excess to military purposes as of the end of 2003 and scheduled for disposition, as well as HEU in civil research reactors and about 1 tonne of HEU that has been returned from civil foreign research reactors since 1996.

[j] This value includes holdings in non-nuclear weapon states that received US-origin HEU that are not listed separately in this table and countries with Chinese-supplied research reactors (Ghana, Syria, Iran, Nigeria). Pakistan also received Chinese-origin HEU, but is listed separately in this table (see footnote (d). Within this category, the countries with civil HEU stocks larger than 5 kg are Argentina; Australia; Austria; Chile; Greece; Iran; Italy; Mexico; Pakistan; Portugal; Romania; Slovenia; Taiwan; and Turkey.