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Nuclear Proliferation: A Historical Overview

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PREFACE

In 2007 the Defense Science Board (DSB) conducted a summer study on challenges to military operations in support of national interests. The DSB created eight panels to study different aspects of potential future conflicts with peer, near-peer, and powerful non-state adversaries. One such panel was asked to explore the military planning implications of nuclear proliferation. Its task was twofold: (1) to provide an assessment of the likely developments in proliferation over the next two decades, and (2) to make recommendations for improved proliferation prevention. To assist with these tasks, the panel needed a sound understanding of historical proliferation experience. An initial research survey indicated a wealth of information about countries of particular concern and about the nonproliferation regime as such, but in contrast there was little available information about and analysis of predominant. trends and the factors that shaped them. To help fill this gap, additional research was conducted under the Institute for Defense Analyses Central Research Program. This work is reported here. The author is grateful to Dr. Michael “Tony” Fainberg and Dr. Brad Roberts for their reviews of earlier drafts of this report.

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SUMMARY

Because of concerns about a potential cascade of nuclear proliferation in response to nuclear weapons acquisition by North Korea and Iran, US policymakers are examining past proliferation experience for lessons to aid future national security planning. Are there proliferation trends that we can reasonably project into the future? Is a cascade possible or inevitable? Can more be done to prevent proliferation? In order to answer these questions, it is important to have a clear understanding of historical experience. This document examines the historical record of proliferation. It is intended to help defense planners draw lessons and conclusions from previous waves of proliferation and to anticipate the forms of proliferation that seem most likely in the decade or two ahead.

A great deal of analysis has focused on the intentions of nuclear proliferators. Instead, this analysis focuses on capabilities. Our purpose is to understand how individual countries have developed their technical potential to produce nuclear weapons. The analysis reported here surveys the experience of 52 countries over 57 years as they have taken steps to develop nuclear-related technical capabilities. For each country, key decision points in the development of those capabilities have been gathered, catalogued, and referenced. Those decisions relate to three key attributes: access to fissile material, weapons design and engineering, and treaty status. Each attribute has a spectrum of capability associated with it. The actual technical potential of a country to produce nuclear weapons is a function of its place on these spectrums. As further explained in the body of the report, we distinguish four basic levels of weapons potential: nil, modest, high, and "for serial production."

The analysis was conducted by regions: South America, the Middle East, Asia, and Europe. Countries that are internationally recognized under the Nuclear Non-Proliferation Treaty as having the right to possess nuclear weapons have been excluded from this analysis. Based on decision points, the development of weapons potential of each country has been charted from 1950 to the present. The progressions of each of these countries through the four categories, based on the implications of their decision points, have been mapped.

This work points to some unexpected findings. First, nuclear proliferation history is a good deal more complex than the usual cartoon depiction of an incremental addition of a new nuclear-armed state every few years. Second, there is a great deal of weapons potential latent in

the international system today. And more is coming. Third, nuclear proliferation is not inevitable, in the sense that many states with weapons ambitions have ultimately chosen to posture themselves below the weapons threshold. Indeed, a consequential number of states have actually chosen to shed capability of various kinds. Fourth, proliferation pressures erupt in waves, as a result of a few linchpin countries and the reactions they generate from others within their region. Historical experience points to at least two prior potential nuclear tipping points—one in the 1960s and the other in the 1970s and 1980s. Fifth, the possibility of attenuating those pressures has been well demonstrated historically. Very few of those with the ambition to acquire nuclear weapons have actually gone the distance to produce them. Lastly, there is very little experience of a state being able to significantly short-circuit the developmental pathway by gaining leap-frog technologies from others. Most of those states with high weapons potential or a potential for serial weapons production took a decade or two to get there. All of these lessons have encouraging implications for the nuclear landscape of the future, suggesting that the US can take constructive action now to positively influence its future security environment.

A. METHODOLOGY

To understand historical proliferation experience, this study proceeds as follows.

First, we catalogued the countries with nuclear-related technical capabilities of any kind. This is a total of 52 countries.

Next, we researched the milestones in the development of those capabilities. This research focuses on capabilities, not intentions. The analysis of intention is open to a great deal of uncertainty and interpretation and has in any case been the focus of a great deal of separate scholarship. Those milestones are essentially decision points relating to a country's potential to produce nuclear weapons. These points have been gathered, catalogued, and referenced. This work was conducted with unclassified information. This analysis focused on decisions related to three key factors: access to fissile material, weapons design and engineering capacity, and treaty status.

The first and most important attribute of a state's potential to produce nuclear weapons is its access to fissile material. As is well known, very specialized materials and expertise are necessary. In order to produce weapons-grade material, a country needs to be able to either enrich uranium to weapons grade, or it needs to be able to reprocess spent plutonium from a nuclear reactor. There are six different uranium enrichment technologies: gaseous diffusion, centrifuge enrichment, electromagnetic isotope separation, chemical and ion exchange enrichment, aerodynamic isotope separation, and laser enrichment. Any one of these six can be used to produce weapons grade uranium. However, some of these technologies are more efficient than others. Laser and chemical enrichment in particular are largely inefficient for the production of fissile material for weapons purposes. There are three technologies for producing plutonium: graphite moderated reactors, heavy water moderated reactors and research reactors. It is important to note that any research reactor with an energy capacity greater than 5 MWt is capable of producing plutonium. However, only research reactors with a capacity of at least 20MWt produce an amount of plutonium that is generally considered sufficient to support an indigenous nuclear weapons production effort. A separation/reprocessing capacity must also be developed in order for a state to be able to produce weapons grade plutonium. These capabilities are difficult to achieve because both the raw materials and the technologies associated with special nuclear materials are carefully monitored by export controls and International Atomic Energy Agency safeguards. Producing fissile material is also, arguably, the most time-intensive and expensive aspect of a weapons development program. [The author would like to note that Europe represents a unique case in the analysis of access to fissile material. In Europe, a unique attempt has been made, in the form of URENCO, to create a multi-national fuel cycle capability.

We have attributed the associated capabilities that URENCO has developed to the countries within which the nuclear facilities are located while simultaneously recognizing that the legal status of such facilities is more complex.]

The second key attribute of a state's weapons potential is its science and engineering capacity. This is obviously central to its ability to design, engineer, and produce a functioning nuclear explosive device. Also obviously, the technical demands associated with different types of devices are not equal. A pure fission bomb is comparatively the simplest nuclear weapon to make. Even with the simplest design, however, complex theoretical calculations and extensive experimentation are also an important part of the indigenous nuclear proliferation pathway. Theoretical studies include the investigation of the physical and chemical behaviors of materials at high temperatures and pressures, the processes of nuclear fission in an explosion, and methods to extrapolate laboratory results to the conditions of an actual nuclear explosion. Designing a gun-type device requires experimentation with criticality—specifically, how to bring the subcritical masses together in order to produce a sustained chain reaction. Engineers must also develop expertise in properly shaping charges, devising a neutron initiator, creating a system to trigger the initiator, etc. Advanced equipment is also necessary to perform requisite testing and calculations to perfect the weapon's design. The equipment required for these tests is so advanced that only a few developed countries have it. Further, the equipment has such selective functionality that great caution is used when exporting it. However, it is important to note that less complex nuclear weapon designs, such as implosion devices, would require less sophisticated technology. Even so, for countries with a limited scientific and engineering base it would be a struggle to find the human capital and equipment necessary to indigenously build a nuclear weapons capacity.

At present, many of the countries seeking nuclear technologies are less scientifically advanced countries. Thus, their potential for quickly acquiring a high-latency capability is diminished. However, a synergistic relationship exists between the development of nuclear research facilities or a nuclear power infrastructure, and the development of the scientific and engineering expertise for a military nuclear program. Civil programs provide an invaluable training ground and a means of gaining experience. Also, countries contracted to build a nuclear facility are also generally contracted to train host country scientists and engineers on the proper use of those facilities. This training and the experience gained from operating a nuclear facility give scientists and engineers a greater understanding of nuclear matters that have both military and civilian applications. Thus, such training provides the opportunity for potential proliferators to develop the expertise to build a nuclear weapons program in a much shorter time than would have been manageable if no such outside assistance were available.

The third attribute in a state's weapons potential is its status within the international non-proliferation treaty (NPT) regime. The three main treaties/agreements of concern are the Nuclear Non-Proliferation Treaty, individual comprehensive safeguards agreements with the IAEA, and the ratification of the Additional Protocol. States parties to this regime face important barriers to their efforts to acquire fissile materials, fuel cycle technologies, and nuclear-related science and engineering capabilities treaties. The more unimpeded access the IAEA has to a country's nuclear facilities, the more likely it is that any illicit activities undertaken will be detected and addressed. Such oversight helps to deter states from breaking their NPT commitment not to pursue nuclear weapons, because it increases the likelihood that a country will be punished for an infraction. These agreements also lengthen the time it will take a country to develop the indigenous capacity to produce fissile material, because many exports of sensitive nuclear materials are subject to IAEA safeguards. Thus, diverting an import to an illicit nuclear weapons program becomes substantially more difficult when the IAEA has to be able to monitor the use of that import.

For each of these three attributes, we attempted to identify the key decision points by which a country improved its technical potential for the production—or chose not to do so, or actually reduced its technical potential.

We then created a framework for comparing the experiences of different countries and regions. Toward this end, we found it helpful to define four basic categories of the potential to produce nuclear weapons, as follows.

A state with *nil weapons potential* is defined by all of the following key factors:

1. Access to fissile material is limited to research reactors with an energy capacity of 20 MWt or less, which would not be able to produce more than one bomb's worth of plutonium per year, and that under optimistic assumptions.
2. The requisite weapons design and engineering capability is lacking because there is not a strong indigenous science and technology base in the disciplines required for these fields.
3. The country is a party to the NPT and is fully compliant with its safeguards obligations.

A state with *modest weapons potential* is defined by all of the following key factors:

1. Access to fissile material is more advanced. States in this category have a nuclear power industry, three or more research reactors, or a single heavy water research reactor in combination with possession of a pilot plutonium separation/reprocessing facility—each of these attributes provide a substantial, expandable expertise in nuclear sciences.

2. The requisite design and engineering capability is more substantial, insofar as countries in this category have some national base of science and technology, providing states in this category with the necessary expertise from which to draw upon to develop nuclear weapons if they choose to do so.
3. It is a party to the NPT and fully compliant with its safeguards obligations.

A state with *high weapons potential* is defined by one of the following factors:

1. Access to fissile material is considerably more advanced. States in this category have either a uranium enrichment capability (which means it could withdraw from the treaty regime and be able to build nuclear weapons in a relatively short period of time), or
2. It has at least a 20 MWt nuclear energy facility in combination with a fully operational separation/reprocessing facility, or
3. It has a robust scientific and engineering capability for nuclear weapons design and has conducted enrichment and/or separation experiments that were undeclared and un-safeguarded, in violation of NPT safeguards.

A state with the *potential for serial weapons production* is defined by the following key factors:

1. It has a closed fuel cycle providing unimpeded access to the fissile material necessary for making nuclear weapons
2. It has a substantial weapons design and engineering capability enabling it to competitively develop and produce nuclear weapons and
3. The country is not a member of the NPT and does not have comprehensive safeguards with the International Atomic Energy Agency.

Without exception, countries within this category possess all three of these attributes.

Figure 1 displays these different capability thresholds and categories.

Attributes / Weapons Potential	Fissile Material Access	Weapons Design & Engineering	Treaty Status
Red: Potential for Serial Production	Closed Fuel Cycle	Basis for Competitive Development	Non Members
Orange: High Weapons Potential	Enrichment and/or Reprocessing	Robust Scientific and Engineering Capability	Additional Protocol Not Fully Implemented (with exceptions)
Yellow: Modest Weapons Potential	Substantial Nuclear Power Industry	Capabilities Latent in National S&T Base	Party to NPT + In Full Compliance w/ Safeguards Obligations
Green: Nil Weapons Potential	Research Reactors	Severely Constrained	Party to NPT + In Full Compliance w/ Safeguards Obligations

Figure 1. Criteria for Defining Nuclear Weapons Capability

As a final step in our methodology, we plotted this data graphically but also somewhat selectively. The selections were made to highlight those decisions and actions that moved a country from one basic category to another. The subsequent sections of this document report the results of this effort by each of the global subregions. It closes with an effort to utilize this data to look for patterns and lessons of potential policy interest.

B. LATIN AMERICA

The history of the development of nuclear weapons potential in this region encompasses the experiences of the following countries:

- Argentina
- Brazil
- Chile
- Colombia
- Mexico
- Peru
- Venezuela

A graphic depiction of these histories appears at figure 2 at the end of this section.

Argentina

Argentina's nuclear program began in 1950 when it created the National Atomic Energy Commission (CNEA). It started to mine uranium and process uranium ore, and in 1958 a US-designed research reactor (RA-1) was completed. The development of these nuclear capabilities placed Argentina in the category of Nil Weapons Potential. In 1967, using RA-1 plans, Argentina independently built three more research reactors. This development moved Argentina into the Modest Weapons Potential category. In 1990 Argentina's gaseous diffusion enrichment facility became operational, moving Argentina into the High Weapons Potential category because it now had the ability to enrich uranium in addition to the fact that it had not yet signed the NPT. In 1994 the gaseous diffusion enrichment facility was shut down, however, and Argentina ratified the Treaty of Tlatelolco. In 1995 Argentina ratified the NPT. These developments moved Argentina back down into the Modest Weapons Potential category. In 2000 Argentina began development of Sigma gaseous diffusion process- building a pilot plant. This development moved Argentina back up into the High Weapons Potential category. As of 2007, Argentina has yet to sign or ratify the Additional Protocol.

Key timeline data:

1950: National Atomic Energy Commission (CNEA) created. See Julio C. Carasales, "The So-Called Proliferator that Wasn't: The Story of Argentina's Nuclear Policy," *Nonproliferation Review*, Vol. 6, No. 4 (Fall 1999), p. 52.

1953: Uranium mining began. See Analytical Center for Non-Proliferation, Annex 8, http://npc.sarov.ru/english/digest/22001/appendixe8.html (accessed <7/2/2007>).

1954: Uranium ore processing plant became operational. See Analytical Center for Non-Proliferation, Annex 8, http://npc.sarov.ru/english/digest/22001/appendixe8.html (accessed <7/2/2007>).

1958: US designed research reactor, RA-1, built (10 kW). See Analytical Center for Non-Proliferation, Annex 8, http://npc.sarov.ru/english/digest/22001/appendixe8.html (accessed <7/2/2007>).

1967: Using RA-1 plans, Argentina independently built three more research reactors (a 5MWt, Source: Analytical Center for Non-Proliferation, Annex 8, http://npc.sarov.ru/english/digest/22001/appendixe8.html (accessed <7/2/2007>).

1967-8: Rejected Nuclear Non-Proliferation Treaty (NPT) and purchased a heavy water reactor from West Germany. See Julio C. Carasales "The So-Called Proliferator that Wasn't: The Story of Argentina's Nuclear Policy," *Nonproliferation Review*, Vol. 6, No. 4 (Fall 1999), p. 54.

1968: Built a plutonium extraction facility (laboratory-scale and not safeguarded). See M.D. Zentner, G.L. Coles, and R.J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 92.

1973: Closed the plutonium extraction facility (having reportedly extracted < 1 kg Pu). See Analytical Center for Non-Proliferation, Annex 8, http://npc.sarov.ru/english/digest/22001/appendixe8.html (accessed <7/2/2007>).

1976: Military coup, which fueled drive for nuclear self-sufficiency. See Analytical Center for Non-Proliferation, Annex 8, http://npc.sarov.ru/english/digest/22001/appendixe8.html (accessed <7/2/2007>).

1978: Construction began on a second, commercial scale reprocessing facility. See Analytical Center for Non-Proliferation, Annex 8, http://npc.sarov.ru/english/digest/22001/appendixe8.html (accessed <7/2/2007>).

1979: Construction began on a secret, un-safeguarded uranium enrichment facility. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 11.

Late 1970s: Air Force began work on Condor missile delivery system. See GlobalSecurity.org, "Argentina: Missile Programs," http://www.globalsecurity.org/wmd/world/argentina/missile.htm# (accessed <7/3/2007>).

1982: Fuel fabrication plant and conversion (UO2) plant became operational. See Analytical Center for Non-Proliferation, Annex 8, http://npc.sarov.ru/english/digest/22001/appendixe8.html(accessed <7/2/2007>).

1983: Military junta was replaced by an elected government and CNEA was placed under civilian direction. See Analytical Center for Non-Proliferation, Annex 8, http://npc.sarov.ru/english/digest/22001/appendixe8.html (accessed <7/2/2007>).

1985: Argentina and Brazil agreed to nuclear confidence building measures. See Julio C. Carasales "The So-Called Proliferator that Wasn't: The Story of Argentina's Nuclear Policy," *Nonproliferation Review*, Vol. 6, No. 4 (Fall 1999), p. 57.

1987: Special alloy fabrication facility operational. Reciprocal visits with Brazil also began. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 11.

1988: Heavy-water production facility became operational. See Analytical Center for Non-Proliferation, Annex 8, http://npc.sarov.ru/english/digest/22001/appendixe8.html (accessed <7/2/2007>).

1990: Pilcaniyeu gaseous diffusion uranium enrichment facility operational (20 MTSWU/year). See IAEA Nuclear Fuel Cycle Information System, http://www-nfcis.iaea.org/NFCIS/NFCISMain.asp?RPage=1&RightP=List (accessed <3/2/2008>).

1991: Reprocessing facility was shut down. See Analytical Center for Non-Proliferation, Annex 8 http://npc.sarov.ru/english/digest/22001/appendixe8.html (accessed <7/2/2007>).

1994: Gaseous diffusion enrichment facility was shut down. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 11

1994: Argentina ratified Treaty of Tlatelolco. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Argentina.pdf (accessed <7/3/2007>).

1995: Argentina ratified Nuclear Non-Proliferation Treaty. See IAEA.org, "Country Profile: Argentina," http://www.iaea.org/DataCenter/index.html (accessed <8/7/2007>).

1998: Argentina ratified Comprehensive Test-Ban Treaty. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Argentina.pdf (accessed <7/3/2007>).

2000: Began development of Sigma gaseous diffusion process and built pilot plant. Uranium enrichment facility subjected to IAEA safeguards. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 11.

Status in 2007: Argentina is not a signatory to Additional Protocol. It has two operational nuclear power plants plus one plant under construction. It is also a member of the Missile Technology Control Regime. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Argentina.pdf (accessed <7/3/2007>).

Brazil

Brazil's nuclear program began in 1954 when it established the National Nuclear Energy Commission (CNEN). By 1957 its 1st nuclear research reactor was operational (5,000 Kw). These developments placed Brazil in the category of Nil Weapons Potential. In 1975 Brazil's military engaged a parallel nuclear program—"Solimões"—to develop nuclear weapons. With the cooperation of the Institute for Energy and Nuclear Research (IPEN), the Navy developed ultra-centrifuges for uranium enrichment; the Army chose plutonium production reactors. The Air Force undertook research on laser enrichment of uranium, as well as nuclear weapons design and the construction of a nuclear test site. This development moved Brazil into the Modest Weapons Potential category. In 1979 the Pilot Uranium Enrichment Plant became operational. This development caused Brazil to move into the High Weapons Potential category. In 1981 the Brazilian Navy's laboratory-scale uranium enrichment facility became operational and a uranium ore processing facility also became operational, solidifying Brazil's placement in the High Weapons Potential category. In 1998 Brazil ratified the NPT; however, Brazil has yet to sign or ratify the Additional Protocol.

Key timeline data:

1954: National Nuclear Energy Commission (CNEN) was established. See Jean Krasno, "Brazil's Secret Nuclear Program," *Orbis*, Vol. 38, No. 4 (Summer 1994), p. 425-438.

1957: First nuclear research reactor became operational (5,000 Kw). See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/10/2007>).

1960s: With US assistance, Brazil began a sounding rocket program. See Wyn Q. Bowen, "Report: Brazil's Accession to the MTCR," *Non-Proliferation Review*, Vol. 3, No. 3 (Summer/Spring 1996), p. 86.

1964: Military rule was established. See Jean Krasno, "Brazil's Secret Nuclear Program," *Orbis*, Vol. 38, No. 4 (Summer 1994), pp. 425-438

1967-8: Brazil rejected the NPT. See Jean Krasno, "Brazil's Secret Nuclear Program," *Orbis*, Vol. 38, No. 4 (Summer 1994), pp. 425-438

1975: Deal made with West Germany to provide complete fuel cycle technology, two power reactors and a commercial-scale uranium enrichment facility (un-safeguarded). See Analytical Center for Non-Proliferation, Annex 8, http://npc.sarov.ru/english/digest/22001/appendixe8.html (accessed <7/2/2007>).

1975: Military created a parallel nuclear program called Solimões. With the cooperation of the Institute for Energy and Nuclear Research (IPEN), the Navy developed ultra-centrifuges for uranium enrichment; the Army chose plutonium production reactors. The Air Force undertook research on laser enrichment of uranium, as well as nuclear weapons design and the construction of a nuclear test site. See Jean Krasno, "Brazil's Secret Nuclear Program," *Orbis*, Vol. 38, No. 4 (Summer 1994), pp. 425-438 and Analytical Center for Non-Proliferation, Annex 8, http://npc.sarov.ru/english/digest/22001/appendixe8.html (accessed <7/2/2007>).

1979: Regime created the Brazilian Complete Space Mission (MECB), with a central military role. See Wyn Q. Bowen, "Report: Brazil's Accession to the MTCR," *Non-Proliferation Review*, Vol. 3, No. 3 (Summer/Spring 1996), p. 86.

1979: Pilot Uranium Enrichment Plant operational (0 MTSWU/year). See IAEA Nuclear Fuel Cycle Information System, http://www-nfcis.iaea.org/NFCIS/NFCISMain.asp?RPage=1&RightP=List (accessed <3/2/2008>).

1980s: Navy developed ultra centrifuges for uranium enrichment. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 23.

1981: Navy-developed laboratory-scale uranium enrichment facility became operational, as did uranium ore processing facility. See Analytical Center for Non-Proliferation, Annex 8, http://npc.sarov.ru/english/digest/22001/appendixe8.html (accessed <7/2/2007>).

1982: Laboratory-scale spent fuel reprocessing and commercial-scale fuel fabrication facilities became operational. See Analytical Center for Non-Proliferation, Annex 8, http://npc.sarov.ru/english/digest/22001/appendixe8.html (accessed <7/2/2007>).

1982: 1^{st} nuclear power reactor operational. See IAEA Power Rector Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/10/2007>).

1984: Pilot plant conversion (UF6) facility became operational. See Analytical Center for Non-Proliferation, Annex 8, http://npc.sarov.ru/english/digest/22001/appendixe8.html (accessed <7/2/2007>).

1986: Conversion to uranium metal facility became operational (pilot plant). See Sharon Squassoni and David Fite, "Brazil as Litmus Test: Resende and Restrictions on Uranium Enrichment," *Arms Control Today*, Vol. 35, No. 8 (October 2005).

1987: Navy successfully enriched uranium. See Yana Feldman, "Brazil," *First Watch International* (July 2006), p. 3.

1988: Parallel nuclear weapons program became official and was made public. See Yana Feldman, "Brazil," *First Watch International* (July 2006), p. 3.

1988: Gas centrifuge uranium enrichment laboratory (BRN Enrichment) operational (5 MTSWU/year). See IAEA Nuclear Fuel Cycle Information System, http://www-nfcis.iaea.org/NFCIS/NFCISMain.asp?RPage=1&RightP=List (accessed <3/2/2008>).

1989: Pilot Uranium Enrichment Plant was decommissioned. See Analytical Center for Non-Proliferation, Annex 8, http://npc.sarov.ru/english/digest/22001/appendixe8.html (accessed <7/2/2007>).

1990: Brazil's president asked military to stop Solimões Project. See Sharon Squassoni and David Fite, "Brazil as Litmus Test: Resende and Restrictions on Uranium Enrichment," *Arms Control Today*, Vol. 35, No. 8 (October 2005).

1993: Laboratory-scale spent fuel reprocessing facility decommissioned. See IAEA Nuclear Fuel Cycle Information System, http://www-nfcis.iaea.org/NFCIS/NFCISMain.asp?RPage=1&RightP=List (accessed <3/2/2008>).

1994: Brazil ratified Treaty of Tlatelolco and IAEA safeguards. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Brazil.pdf (accessed <7/3/07>).

1995: Brazil became a member of the Missile Technology Control Regime. See Wyn Q. Bowen, "Report: Brazil's Accession to the MTCR," *The Non-Proliferation Review*, Vol. 3, No. 3 (Summer/Spring 1996), p. 86.

1998: Brazil ratified Nuclear Non-Proliferation Treaty and Comprehensive Test-Ban Treaty. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Brazil.pdf (accessed <7/3/07>).

1998: Pilot gas centrifuge uranium enrichment plant (BRF Enrichment) became operational (4 MTSWU/year). See IAEA Nuclear Fuel Cycle Information System, http://www-nfcis.iaea.org/NFCIS/NFCISMain.asp?RPage=1&RightP=List (accessed <3/2/2008>).

2005: Commercial scale uranium enrichment plant (Resende Enrichment, 120 MTSWU/year) became operational. Also, after a lengthy and tense debate, Brazil reached a safeguards agreement with the IAEA. See IAEA Nuclear Fuel Cycle Information System, http://www-nfcis.iaea.org/NFCIS/NFCISMain.asp?RPage=1&RightP=List (accessed <3/2/2008>).

Status in 2007: Brazil is not a signatory to the Additional Protocol. It has two operational nuclear power plants with seven more planned. The Navy continues to be heavily involved in the uranium enrichment program. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Brazil.pdf (accessed <7/3/2007>), and Sharon Squassoni and David Fite, "Brazil as Litmus Test: Resende and Restrictions on Uranium Enrichment," *Arms Control Today*, Vol. 35, No. 8 (October 2005).

Chile

In 1974 Chile's first research reactor became operational. In 1995 Chile ratified the Nuclear Non-Proliferation Treaty, and in 2003 it ratified the Additional Protocol. This history places Chile in the category of Nil Weapons Potential, because since the inception of its nuclear program, its capabilities have been limited to nuclear research.

Key timeline data:

1974: first research reactor became operational.

1989: second research reactor operational.

1995: ratified Nuclear Non-Proliferation Treaty.

2000: ratified Comprehensive Test-Ban Treaty.

2003: ratified Additional Protocol.

Status in 2007: One operational research reactor (having shut down the one that became operational in 1989). The Chilean Commission on Nuclear Energy had made it clear in recent years that nuclear power continues to be an open option for the country. In 2006, responding to political pressure to solve a potential energy crisis, Chilean Energy Minister Karen Poniachik said the ministry would commence a technical study on the use of nuclear power in Chile.

General sources: http://www.reachingcriticalwill.org/about/pubs/Inventory07/Chile.pdf (accessed <8/3/2007>) and IAEA Research Reactor Data Base http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/3/2007>).

Colombia

In 1965 Colombia's first research reactor became operational. In 1986 Colombia ratified the Nuclear Non-Proliferation Treaty, and as of 2007 had signed, not ratified, the Additional Protocol. This history places Colombia in the category of Nil Weapons Potential because, since the inception of its nuclear program, its capabilities have been limited to nuclear research.

Key timeline data:

1965: first research reactor became operational.

1972: ratified Treaty of Tlatelolco.

1986: ratified Nuclear Non-Proliferation Treaty.

Status in 2007: Colombia does not have any nuclear power facilities and has signed but not ratified the Additional Protocol.

General Sources: http://www.reachingcriticalwill.org/about/pubs/Inventory07/Colombia.pdf (accessed <8/3/2007>) and IAEA Research Reactor Data Base http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/3/2007>).

Mexico

In 1967 Mexico ratified the Treaty of Tlatelolco, and in 1968 its first research reactor became operational. These developments placed Mexico in the category of Nil Weapons Potential because its capabilities were limited to nuclear research. In 1989 Mexico's first nuclear power plant became operational, moving Mexico into the Modest Weapons Potential category because of its technical industrial advances.

Key timeline data:

1967: ratified Treaty of Tlatelolco.

1968: first research reactor became operational.

1969: ratified Nuclear Non-Proliferation Treaty.

1989: first nuclear power plant became operational.

1999: ratified Comprehensive Test-Ban Treaty.

Status in 2007: Mexico has one nuclear power plant and two reactors operational. It has signed but not ratified the Additional Protocol.

General sources: http://www.reachingcriticalwill.org/about/pubs/Inventory07/Mexico.pdf (accessed <8/3/2007>), and IAEA Research Reactor Data Base http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/3/2007>).

Peru

Peru ratified the Treaty of Tlatelolco in 1969 and the Nuclear Non-Proliferation Treaty in 1970. The Peruvian Nuclear Program was initiated in 1975, involving the construction of a basic nuclear infrastructure and human resource training. In 1978 Peru's first research reactor became operational, and in 2001 it ratified the Additional Protocol. This history places Peru in the category of Nil Weapons Potential because, since the inception of its nuclear program, its capabilities have been limited to nuclear research.

Key timeline data:

1969: ratified the Treaty of Tlatelolco.

1970: ratified the Nuclear Non-Proliferation Treaty.

1975: initiated the Peruvian Nuclear Program.

1978: first research reactor became operational.

1988: second research reactor became operational.

1997: ratified the Comprehensive Test-Ban Treaty.

2001: ratified the Additional Protocol.

Status in 2007: Peru does reactor-based research but does not operate any nuclear power plants.

General sources: http://www.reachingcriticalwill.org/about/pubs/Inventory07/Peru.pdf (accessed <8/7/2007>), and IAEA Research Reactor Data Base http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/7/2007>).

Venezuela

In 1960 Venezuela's first research reactor became operational, and in 1975 Venezuela ratified the Nuclear Non-Proliferation Treaty. As of 2007 Venezuela's one nuclear research reactor had been shut down. This history places Venezuela in the category of Nil Weapons Potential because, since the inception of its nuclear program, its capabilities have been limited to nuclear research.

Key timeline data:

1960: first research reactor became operational.

1975: ratified Nuclear Non-Proliferation Treaty.

1994: research reactor was shut down.

Status in 2007: Venezuela does not operate any nuclear power plants and its mothballed research reactor is under IAEA safeguards.

General sources: Federation of Atomic Scientists, "Weapons on Mass Destruction: Treaty on the Non-Proliferation of Nuclear Weapons," http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/7/2007>), and IAEA Research Reactor Data Base http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/7/2007>).

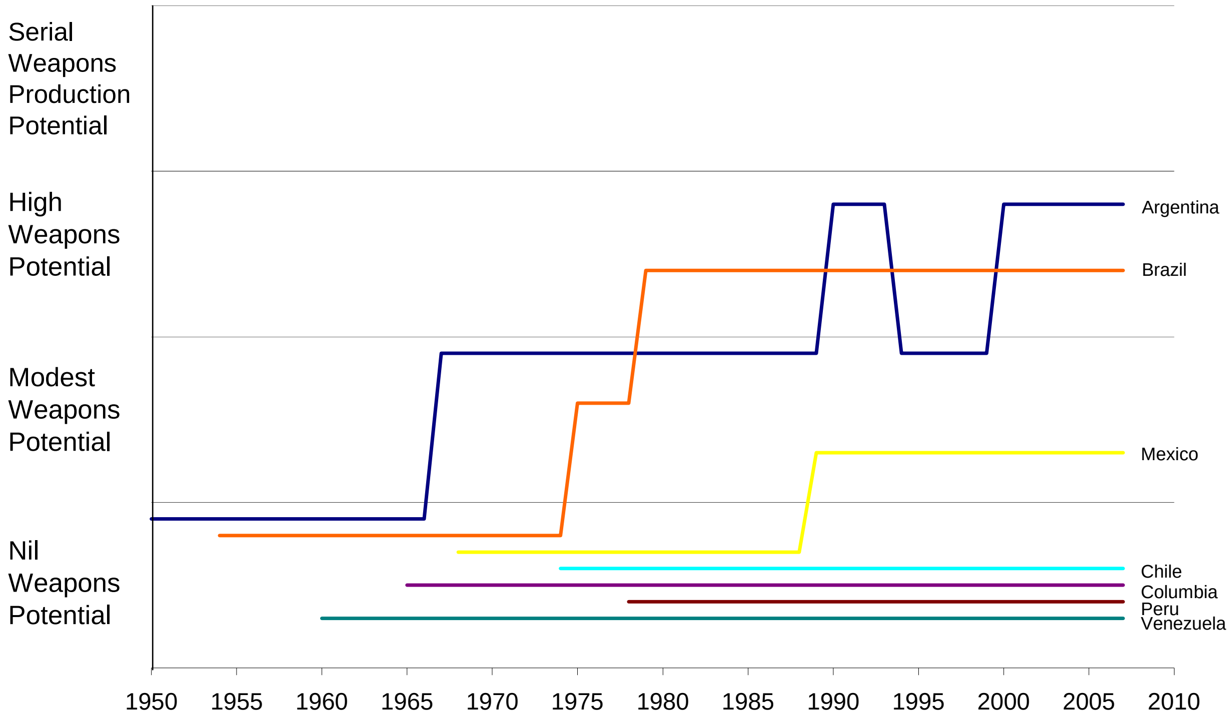

Figure 2. Latin America's Nuclear Proliferation History

C. MIDDLE EAST AND AFRICA

Nuclear history in the Middle East and Africa encompasses the experiences of the following countries:

- Algeria
- Egypt
- Iran
- Iraq
- Israel
- Libya
- Saudi Arabia
- South Africa
- Syria
- Turkey

A graphic depiction of this information appears at figure 3 at the end of this section.

Algeria

In 1969 Algeria's uranium exploration efforts began, placing Algeria in the Nil Weapons Potential category. In 1981 Algeria announced its intentions to launch a nuclear power program, and by 1989 (1 MWt) its first nuclear research reactor went critical; Algeria tried to conceal this development. In 1991 another research reactor went critical, and in 1993 a third reactor also went online. Algeria moved into the Modest Weapons Potential category when its third research reactor at Es Salam (15 MWt) went critical. A component of the justification for increasing Algeria's nuclear weapons potential to increase is that both of these research reactors were heavy-water CANDU reactors, which are significantly less proliferation resistant than other types of reactors, and produce relatively more plutonium in their spent fuel than light water reactors. Heavy water research reactors such as these may indicate that a country is pursuing a route to producing plutonium. By 1996 a Chinese-supplied hot cell facility and an underground channel connecting the Es Salam reactor to the hot cell facility had been completed. This facility was under IAEA safeguards, however, so Algeria remained in the Modest Weapons potential category. As of 2007 Algeria has not ratified the Additional Protocol and possesses a significant nuclear research infrastructure.

Key timeline data:

1969: Uranium exploration efforts began. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Algeria," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/8/2007>).

1981: Intention to launch a nuclear power program was announced. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Algeria," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/8/2007>).

1984: Algeria purchased 150 tons of uranium concentrate (yellowcake) from Niger. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Algeria.pdf (accessed <8/8/2007>).
Late 1980s: Contractors from Argentina began construction of a fuel fabrication facility. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Algeria," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/8/2007>).

1989: First research reactor went critical (1 MWt light water reactor). See IAEA Research Reactor Data Base http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/8/2007>).

Early 1990s: Algeria was suspected of exploring spent fuel reprocessing process. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Algeria," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/8/2007>).

1991: Construction began on what appeared to be a nuclear fuel reprocessing plant. The 15 MWt heavy-water reactor (Es Salam) went critical. See David Albright and Corey Hinderstein, "Algeria: Big Deal in the Desert?," *Bulletin of the Atomic Scientists*, Vol. 57, Issue 3 (May/June 2001), pp. 47-8.

1992: IAEA was allowed to inspect some nuclear sites in the country (but did not have the authority to inspect all of the facilities at suspect sites). See David Albright and Corey Hinderstein, "Algeria: Big Deal in the Desert?," *Bulletin of the Atomic Scientists*, Vol. 57, Issue 3 (May/June 2001), p. 49.

1993: Second research reactor at Es Salam went critical (15 MWt heavy-water reactor). See David Albright and Corey Hinderstein, "Algeria: Big Deal in the Desert?," *Bulletin of the Atomic Scientists*, Vol. 57, Issue 3 (May/June 2001), p. 50.

1994: Worked with IAEA to investigate methods for the removal and recovery of uranium from phosphate ore. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Algeria," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/8/2007>).

1995: Algeria acceded to the Nuclear Non-Proliferation Treaty. See :http://www.reachingcriticalwill.org/about/pubs/Inventory07/Algeria.pdf (accessed <8/8/2007>).

1996: Completed China-supplied hot cell facility and an underground channel connecting the Es Salam reactor to the hot cell facility. This facility was under IAEA safeguards, but the intelligence community suspected that a larger facility nearby was a large-scale reprocessing facility that was not under IAEA safeguards. See David Albright and Corey Hinderstein, "Algeria: Big Deal in the Desert?," *Bulletin of the Atomic Scientists*, Vol. 57, Issue 3 (May/June 2001), p. 50.

1996: Algeria signed Comprehensive Test-Ban Treaty. See: http://www.reachingcriticalwill.org/about/pubs/Inventory07/Algeria.pdf (accessed <8/8/2007>).

2000: Completed Fuel Fabrication Plant (under IAEA safeguards). See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Algeria," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/8/2007>).

2003: Ratified Comprehensive Test-Ban Treaty. See: http://www.reachingcriticalwill.org/about/pubs/Inventory07/Algeria.pdf (accessed <8/8/2007>).

2004: Received IAEA Broad Approval on Additional Protocol. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/8/2007>).

Status in 2007: Algeria has not ratified the Additional Protocol. It possesses a significant nuclear research infrastructure, including a double-walled facility next to the nuclear facility that could be used for experimenting with high explosives. See David Albright and Corey Hinderstein, "Algeria: Big Deal in the Desert?," *Bulletin of the Atomic Scientists*, Vol. 57, Issue 3 (May/June 2001), pp. 45-52.

Egypt

In 1955 the Egyptian Atomic Energy Authority was created and by 1961 Egypt's first research reactor went critical at Inshas (2MWt). In 1965 and 1967 Egypt attempted to purchase nuclear weapons and/or nuclear weapons technology from the USSR and China, respectively. Its attempts were unsuccessful, however, and in 1981 Egypt ratified the Nuclear Non-Proliferation Treaty. In 1982 Egypt's Hydrometallurgy Pilot Plant for reprocessing plutonium became operational. The facility came equipped with two French-supplied hot cells, but these cells have a minute plutonium processing capacity and the entire facility is under IAEA safeguards. More recently, in 1997, a 20 MWt research reactor supplied by Argentina went critical. As of 2007 Egypt has not ratified the Additional Protocol, does not operate any nuclear power plants today, but possesses a substantial nuclear research infrastructure. This history places Egypt in the category of Nil Weapons Potential because since the inception of its nuclear program its capabilities have been limited to nuclear research.

Key timeline data:

1955: Egyptian Atomic Energy Authority was created. See Robert J. Einhorn, "Egypt: Frustrated but Still on a Non-Nuclear Course," in Kurt M. Campbell, Robert J. Einhorn, and Mitchell B. Reiss (eds) *The Nuclear Tipping Point: Why States Reconsider Their Nuclear Choices* (Washington, D.C.: Brookings Institution Press, 2004), p. 45.

1961: First research reactor at Inshas (2MWt) went critical. See IAEA Research Reactor Data Base http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/8/2007>).

1965: Attempts were made to purchase nuclear weapons and/or nuclear weapons technology from the USSR. See Maria Rost Rublee, "Egypt's Nuclear Weapons Program Lessons Learned," *Nonproliferation Review*, Vol. 13, No 3 (November 2006), p. 559.

1966: Signed letter of intent to purchase a heavy-water reactor, but the deal subsequently collapsed because of a lack of funds. See Robert J. Einhorn, "Egypt: Frustrated But Still on a Non-Nuclear Course," in Kurt M. Campbell, Robert J. Einhorn, and Mitchell B. Reiss (eds.), *The Nuclear Tipping Point: Why States Reconsider Their Nuclear Choices* (Washington, D.C.: Brookings Institution Press, 2004), p. 46.

1967: Attempts were made to purchase nuclear weapons and/or nuclear weapons technology from China. See Robert J. Einhorn, "Egypt: Frustrated but Still on a Non-Nuclear Course," in Kurt M. Campbell, Robert J. Einhorn, and Mitchell B. Reiss (eds) *The Nuclear Tipping Point: Why States Reconsider Their Nuclear Choices* (Washington, D.C.: Brookings Institution Press, 2004), p. 46.

1968: Signed the Nuclear Non-Proliferation Treaty. See Federation of Atomic Scientists, "Weapons on Mass Destruction: Treaty on the Non-Proliferation of Nuclear Weapons," http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/8/2007>)

1981: Ratified NPT and safeguards agreement with the IAEA. See IAEA.org, "Country Profile: Egypt," http://www.iaea.org/DataCenter/index.html (accessed <8/8/2007>).

1982: Hydrometallurgy Pilot Plant for reprocessing plutonium became operational, with two French-supplied hot cells (research facility under IAEA safeguards). See Barbara M. Gregory, "Egypt's Nuclear Program: Assessing Supplier-Based and Other Developmental Constraints," *Nonproliferation Review*, Vol. 3, No. 1 (Fall 1995), p. 23.

1985: Established a joint nuclear cooperation program with Iraq and Pakistan. See Leonard S. Spector with Jacqueline R. Smith, *Nuclear Ambitions the Spread of Nuclear Weapons 1989-1990* (Boulder, Colo.: Westview Press, 1990), pp. 196-97.

1986: Suspended plans to pursue a nuclear power program indefinitely as a consequence of the accident at Chernobyl. See Mohammad El-Sayed Selim, "Egypt and the Middle Eastern Nuclear Issue," *Strategic Analysis* (January 1996), p. 1389.

1988: Laboratory-scale fuel fabrication facility became operational. See Barbara M. Gregory, "Egypt's Nuclear Program: Assessing Supplier-Based and Other Developmental Constraints," *Nonproliferation Review*, Vol. 3, No. 1 (Fall 1995), p. 23.

1997: 20 MWt research reactor supplied by Argentina went critical. See IAEA Research Reactor Data Base http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/8/2007>).

1998: Fuel Manufacturing Pilot Plant became operational under IAEA safeguards. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Egypt," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/8/2007>).

Status in 2007: Has not ratified the Additional Protocol. Does not operate nuclear power plants. Possesses a substantial nuclear research infrastructure, but has yet to establish facilities in the fields of uranium mining, milling, conversion, enrichment, or reprocessing (although experimentation has probably occurred in all but enrichment processes). Has not ratified the Comprehensive Nuclear Test-Ban Treaty. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Egypt.pdf (accessed <8/8/2007>).

Iran

In 1967 Iran's first research reactor, at Tehran Nuclear Research Center (TNRC), went critical. The reactor used 5.585 kg of 93 percent HEU and the facility came equipped with hot cells. These hot cells gave Iran the capacity to produce small amounts (0.6 kg per year) of plutonium. This placed Iran in the category of Modest Weapons Potential because Iranian technicians could use the facilities to gain the scientific knowledge and competence necessary to operate a larger-scale plant. In 1975 construction began on two West German nuclear power units at Bushehr. By 1979 Unit 1 was 90% complete with 60% of the equipment installed with an estimated completion time of 3 years. The 1979 Iranian Revolution interrupted construction at Bushehr, and even though it did not remove the established science and technology base, most nuclear activities ceased. Thus, Iran moved down into the Nil Weapons Potential category. In 1987 Iran commissioned a study on the possibility of acquiring a nuclear weapon. Additionally, the Iranian Revolutionary Guard allegedly began a project to extend the range of the Silkworm missile and to make it nuclear capable. In 1987 Iran also received centrifuge drawings and began importing centrifuge components and cascade designs. These developments placed Iran back up in the Modest Weapons Potential category. In 1998, the centrifuge testing program began at the Kalaye Electric Company's pilot centrifuge facility, and around 2002 the Pilot Fuel Enrichment Plant at Natanz became operational. These developments placed Iran in the High Weapons category. As of 2007, Iran has not ratified the Additional Protocol, the Bushehr reactor has been connected to the Iranian electricity grid – though it is still not producing electricity, and Iran claims to have acquired a commercial-scale uranium enrichment capability. These developments firmly cement Iran in the High Weapons Potential category.

Key timeline data:

1967: Iran's first research reactor (5 MWt), at Tehran Nuclear Research Center (TNRC), went critical. The reactor used 5.585 kg of 93 percent HEU and the facility was equipped with hot cells. See Andrew Koch and Jeanette Wolf, "Iran's Nuclear Facilities: A Profile," *Center for Nonproliferation Studies* (1998), p.10 http://cns.miis.edu/pubs/reports/pdfs/iranrpt.pdf (accessed <8/8/2007>).

1970: Iran ratified Nuclear Non-Proliferation Treaty. See Federation of Atomic Scientists, "Weapons on Mass Destruction: Treaty on the Non-Proliferation of Nuclear Weapons," http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/8/2007>).

1970s: Laser enrichment program began, leading to suspicions that Iran was experimenting with nuclear weapons design, extraction and enrichment. See Andrew Koch and Jeanette Wolf, "Iran's Nuclear Facilities: A Profile," *Center for Nonproliferation Studies* (1998), pp.11-12, http://cns.miis.edu/pubs/reports/pdfs/iranrpt.pdf (accessed <8/8/2007>).

Mid 1970s: numerous contracts were issued for construction of NPU and for nuclear fuel supply. The Nuclear Technology Center at Isfahan was established. See Andrew Koch and Jeanette Wolf, "Iran's Nuclear Procurement Program: How Close to the Bomb?," *Nonproliferation Review*, Vol. 5, No. 1 (Fall 1997), p. 129.

1974: Atomic Energy Organization of Iran was established and a safeguards agreement with the IAEA was ratified. See IAEA.org, "Country Profile: The Islamic Republic of Iran," http://www.iaea.org/DataCenter/index.html (accessed <8/8/2007>).

1975: Construction began on two West German nuclear power units at Bushehr. See Jill Marie Parillo, "Iran's Nuclear Program," *Carnegie Fact Sheet* (September 2006), p. 5.

Late 1970s: US obtained intelligence that the Shah had constituted a clandestine nuclear weapons program. See Leonard S. Spector, *Going Nuclear: The Spread of Nuclear Weapons 1986-1987* (Cambridge: Ballinger Publishing Company, 1987), pp. 50-51.

1979: Iranian revolution began, interrupting construction at Bushehr. See Andrew Koch and Jeanette Wolf, "Iran's Nuclear Facilities: A Profile," *Center for Nonproliferation Studies* (1998), p.1, http://cns.miis.edu/pubs/reports/pdfs/iranrpt.pdf (accessed <8/8/2007>).

1980s: Laboratory-scale experiments were conducted on the production of heavy water. See GlobalSecurity.org, "WMD Facilities: Iran," http://www.globalsecurity.org/wmd/world/iran/arak.htm (accessed <8/8/2007>).

1985: Iran decided to begin a gas-centrifuge enrichment program. See M. D. Zentner, G. L. Coles, and R. J. Talbert, “Nuclear Proliferation Technology Trends Analysis,” Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 27.

1986: Iran allegedly signed a secret nuclear cooperation agreement with Pakistan. See Kenneth R. Timmerman, "Weapons of Mass Destruction: The Cases of Iran, Syria and Libya," a Simon Wiesenthal Center Special Report, August 1992.

1987: Iranian regime commissioned a study on the possibility of Iran acquiring a nuclear weapon. See Alon Pinkas, "Thinking the Unthinkable About Iran," *Jerusalem Post*, 23 April 1992; in Lexis-Nexis, http://www.lexis-nexis.com/ (accessed 8/8/2007>).

1987: Iranian Revolutionary Guard allegedly began a project to extend the range of the silkworm missile and to make it nuclear capable. See “Nuclear Facilities,” *Middle East Defense News*, 8 June 1992; in Lexis-Nexis, http://www.lexis-nexis.com/ (accessed <8/8/2007>).

1987: Iran received centrifuge drawings and began importing centrifuge components and cascade designs. See Jacqueline Shire and David Albright, “Iran’s NPT Violations – Numerous and Possibly On-Going?,” *The Institute for Security Studies* (September 29, 2006), p .3, http://www.isis-online.org/publications/ iran/irannptviolations.pdf (accessed <8/8/2007>).

1988: Iranian scientists reported that Iran had built a plutonium extraction laboratory at TNRC and had begun extraction experiments. See Andrew Koch and Jeanette Wolf, “Iran’s Nuclear Facilities: A Profile,” *Center for Nonproliferation Studies* (1998), p.11, http://cns.miis.edu/pubs/reports/pdfs/iranrpt.pdf (accessed <8/8/2007>).

1989-90: Two Iranians in the US allegedly illegally exported to Iran equipment that could be used to develop nuclear weapons. See James V. Grimaldi and David Greenwald, *Orange County Register,* 30 August 1991; Cristina Lee, *Los Angeles Times,* 13 September 1991, p. D2.

1992: Efforts at laser isotope separation began at TNRC. Two Chinese-supplied sub-critical reactors were completed at Isfahan. See Andrew Koch and Jeanette Wolf, “Iran’s Nuclear Facilities: A Profile,” *Center for Nonproliferation Studies* (1998), pp.11-12, http://cns.miis.edu/pubs/reports/pdfs/iranrpt.pdf (accessed <8/8/2007>).

1994: A miniature neutron reactor supplied by China went critical at Isfahan. See Andrew Koch and Jeanette Wolf, “Iran’s Nuclear Facilities: A Profile,” *Center for Nonproliferation Studies* (1998), p.16 http://cns.miis.edu/pubs/reports/pdfs/iranrpt.pdf (accessed <8/8/2007>)

1995: A heavy-water research reactor supplied by China went critical at Isfahan. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/8/2007>).

1995: Iran allegedly received advanced P-2 centrifuge drawings from the A.Q. Khan black-market network. See Jacqueline Shire and David Albright, "Iran's NPT Violations – Numerous and Possibly On-Going?," *The Institute for Security Studies* (September 29, 2006), p .3, http://www.isis-online.org/publications/iran/irannptviolations.pdf (accessed <8/8/2007>).

1996: Iran ratified the Comprehensive Test-Ban Treaty. See: http://www.reachingcriticalwill.org/about/pubs/Inventory07/Iran.pdf (accessed <8/8/2007>).

1996: Construction began on a uranium conversion facility at Isfahan. The Isfahan Alloy Steel Complex became operational (producing steel for a Defense Industries Organization munitions plant but also capable of producing high-grade steel for weapons). See GlobalSecurity.org, "WMD Facilities: Iran," http://www.globalsecurity.org/wmd/world/iran/esfahan.htm (accessed <8/8/2007>).

1998: Centrifuge testing program began at the Kalaye Electric Company's pilot centrifuge facility. See Jill Marie Parillo, "Iran's Nuclear Program," *Carnegie Fact Sheet* (September 2006), p. 3.

2002: Pilot Fuel Enrichment Plant at Natanz became operational (estimate). See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 28.

2003: Testing began on a 10-machine centrifuge cascade with UF6—and then halted. See Jill Marie Parillo, "Iran's Nuclear Program," *Carnegie Fact Sheet* (September 2006), p. 5.

2003: Iran signed the Additional Protocol and acknowledged that it had previously imported 1.8 tons of nuclear ore from China that it used to manufacture uranium metal. See Jacqueline Shire and David Albright, "Iran's NPT Violations – Numerous and Possibly On-Going?," *The Institute for Security Studies* (September 29, 2006), p .1, http://www.isis-online.org/publications/iran/irannptviolations.pdf (accessed <8/8/2007>).

2003: Fuel Enrichment Plant at Natanz was still under construction. See GlobalSecurity.org, "WMD Facilities: Iran," http://www.globalsecurity.org/wmd/world/iran/arak.htm (accessed <8/8/2007>).

2004: Began construction on Fuel Manufacturing Plant at Isfahan. Abbas uranium mine also became operational. See GlobalSecurity.org, "WMD Facilities: Iran," http://www.globalsecurity.org/wmd/world/iran/arak.htm (accessed <8/8/2007>).

2005: Small-scale uranium enrichment activities resumed. See Jill Marie Parillo, "Iran's Nuclear Program," *Carnegie Fact Sheet* (September 2006), p. 5.

2006: Heavy Water Production Plant was under construction at Arak. See GlobalSecurity.org, WMD Facilities: Iran," http://www.globalsecurity.org/wmd/world/iran/arak.htm (accessed <8/8/2007>).

Status in 2007: Iran has not ratified the Additional Protocol. The Bushehr reactor is connected to the Iranian electricity grid, though it is still not producing electricity. Iran claims to have acquired a commercial-scale uranium enrichment capability. Jill Marie Parillo, "Iran's Nuclear Program," *Carnegie Fact Sheet* (September 2006), pp. 1-7.

Iraq

In 1956 the Iraqi Atomic Energy Commission was established, and by 1967 Iraq's first research reactor went critical. This placed Iraq in the category of Nil Weapons Potential. In 1976 an Italian-supplied, laboratory-scale, fuel reprocessing facility became operational. In 1979 the construction of Iraq's first nuclear power reactor, Osirak, was complete except for the reactor core, which was cracked in transit. These developments moved Iraq into the Modest Weapons Potential category because of its expanding nuclear science and technology expertise. In 1987 the design work for the third—production—phase of the EMIS project was finalized, with a plan for two plants with 70 R120 separators. By 1990 the EMIS machines were enriching uranium, a bomb design facility (Al Atheer) had opened, and Iraq had produced an exact model for a nuclear weapon made of machined metal parts (implosion device). Additionally, in 1990 Iraq implemented a crash program to extract HEU from Iraq's stock of safeguarded HEU, with the intention to build a nuclear weapon from this material; the effort was a failure. These developments moved Iraq into the High Weapons Potential category. The Gulf War began in 1991, and the Al Atheer facility and Al Tarmiya and Tuwaitha (EMIS) facilities were destroyed by 1992; however, Iraq moved back into the Modest Weapons Potential category. Because Iraq did not completely disclose all of its nuclear facilities to IAEA inspectors, Iraq did not move into the Nil Weapons Potential category until 1995. Hussein Kamel's defection revealed previously undisclosed portions of the Iraqi nuclear weapons program and these were then brought under control. In 2001–02 suspicions began to mount that Saddam had never abandoned his nuclear weapons program, but the 2003 inspections revealed that the nuclear program had not been reconstituted.

Key timeline data:

1956: The Iraqi Atomic Energy Commission was established. See NTI.org, "Iraq Profile," http://www.nti.org/e_research/profiles/Iraq/Nuclear/2121_2122.html (accessed <8/8/2007>).

1967: First research reactor went critical. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/8/2007>).

1969: Iraq ratified the Nuclear Non-Proliferation Treaty. See Federation of Atomic Scientists, "Weapons on Mass Destruction: Treaty on the Non-Proliferation of Nuclear Weapons," http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/8/2007>).

1971: Secret nuclear weapons program was initiated by IAEC. See NTI.org, "Iraq Profile," http://www.nti.org/e_research/profiles/Iraq/Nuclear/2121_2122.html (accessed <8/8/2007>).

1972: IAEA safeguards agreement was reached. See IAEA INFCIRC 172, 22 February 1973, http://www.iaea.org/worldatom/Documents/Infcircs/Others/infcirc172.pdf (accessed <8/8/2007>).

1976: An Italian-supplied, laboratory-scale, fuel reprocessing facility became operational. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 96.

1979: Construction of Osirak was completed except for the reactor core, which was cracked in transit. See NTI.org, "Iraq Profile," http://www.nti.org/e_research/profiles/Iraq/Nuclear/2121_2122.html (accessed <8/8/2007>).

1980: Iraq bought 120 tons of yellowcake from Portugal. See Iraq Watch, "Fact Sheet: Iraq's Nuclear Weapon Program International Atomic Energy Agency" (April 15, 2002), http://www.iraqwatch.org/un/IAEA/iaea-facts-042502.htm (accessed <8/8/2007>).

1981: Research began on laser isotopic separation, both atomic (AVLIS) and molecular (MLIS). See Iraq Watch, "Fact Sheet: Iraq's Nuclear Weapon Program International Atomic Energy Agency" (April 15, 2002), http://www.iraqwatch.org/un/IAEA/iaea-facts-042502.htm (accessed <8/8/2007>).

1981: Israel bombed the Osirak research reactor and destroyed the larger reactor. See David Albright and Mark Hibbs, "Iraq and the Bomb: Were They Even Close?," *The Bulletin of the Atomic Scientists*, Vol. 47, Issue 2 (March 1991), p. 19.

1982: The Office of Studies and Development was created to pursue secret gaseous diffusion, uranium enrichment, and weapons design activities. Pilot plutonium separation facility was operational. Construction began on two different magnet/separator systems. Electromagnetic program began operation. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 96.

1984: The gaseous diffusion separation facility was completed, along with the centrifuge production facility. The Al Qain facility began producing yellowcake. See Iraq Watch, "Fact

Sheet: Iraq's Nuclear Weapon Program International Atomic Energy Agency," (April 15, 2002) http://www.iraqwatch.org/un/IAEA/iaea-facts-042502.htm (accessed <8/8/2007>).

Mid 1980s: Iraq began a plasma physics program for "peaceful" fusion research. See Khidhir Hamza, "Inside Saddam's Secret Nuclear Program," *Bulletin of the Atomic Scientists*, Vol. 54, Issue 5 (September/October 1998) http://www.iraqwatch.org/perspectives/bas-hamza-iraqnuke-10-98.htm (accessed <8/8/2007>).

1987: Design work was finalized for the third, production phase of the EMIS project, calling for two plants with 70 R120 separators. See Iraq Watch, "Fact Sheet: Iraq's Nuclear Weapon Program International Atomic Energy Agency," April 15, 2002, http://www.iraqwatch.org/un/IAEA/iaea-facts-042502.htm (accessed <8/8/2007>).

1989: Gaseous diffusion program was cancelled. See Federation of Atomic Scientists, "Weapons on Mass Destruction: Iraq," http://www.fas.org/nuke/guide/iraq/nuke/program.htm (accessed <8/8/2007>).

1990: EMIS machines began enriching uranium. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 40.

1990: R120 separators with feed stock were installed and commissioned. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 40.

1990: Bomb design facility (Al Atheer) was opened. An exact model of a nuclear weapon (implosion device) was produced of machined metal parts. See David Albright and Mark Hibbs, "Iraq and the Bomb: Were They Even Close?," *The Bulletin of the Atomic Scientists*, Vol. 47, Issue 2 (March 1991), pp. 18-19.

1990: Saddam authorized a crash program to extract HEU from Iraq's stock of safeguarded HEU fuel, with the intention to build a nuclear weapon. The effort failed. See Federation of Atomic Scientists, "Weapons on Mass Destruction: Iraq," http://www.fas.org/nuke/guide/iraq/nuke/program.htm (accessed <8/8/2007>).

1992: War and subsequent actions brought destruction of the Al Atheer, Al Tarmiya, and Tuwaitha (EMIS) facilities. See NTI.org, "Iraq Profile," http://www.nti.org/e_research/profiles/Iraq/Nuclear/2121_2122.html (accessed <8/8/2007>).

1994: Khidhir Hamza defected, bringing further detailed information about the Iraqi nuclear weapons program. See NTI.org, "Iraq Profile," http://www.nti.org/e_research/profiles/Iraq/Nuclear/2121_2122.html (accessed <8/8/2007>).

1995: Hussein Kamel defected, revealing previously undisclosed portions of the program, including the 1990 crash extraction program. See David Albright and Robert Kelley, "Has Iraq Come Clean At Last?," *The Bulletin of Atomic Scientists*, Vol. 51, Issue 6 (November/December 1995), p. 53.

1998: Iraq expelled UNSCOM weapons inspectors. See NTI.org, "Iraq Profile," http://www.nti.org/e_research/profiles/Iraq/Nuclear/2121_2122.html (accessed <8/8/2007>).

2000: IAEA inspectors were allowed back into the country. See NTI.org, "Iraq Profile," http://www.nti.org/e_research/profiles/Iraq/Nuclear/2121_2122.html (accessed <8/8/2007>).

2003: After coalition invasion of Iraq, inspections did not reveal a reconstituted nuclear program. See *Comprehensive Report of the Special Advisor to the DCI on Iraq's WMD, September 30, 2004,* http://www.cia.gov/cia/reports/iraq_wmd_2004/index.html.

Status in 2007: All known nuclear facilities are monitored by US military personnel.

Israel

In 1952 Israel secretly founded the Israeli Atomic Energy Commission (IAEC) under the control of the Israeli Defense Ministry, and in 1953 Israeli scientists perfected the uranium extraction process and developed a new procedure for making heavy water. The development of these nuclear capabilities brought Israel in the category of Nil Weapons Potential. In 1962 the Dimona reactor went critical (un-safeguarded and secured by the military), moving Israel into the Modest Weapons Potential category. In 1964 Israel's plutonium processing facility became operational, moving Israel into the High Weapons Potential category. By 1966 Israel was capable of producing weapons-grade fissile material, weapons design, and the testing of delivery-means. These developments placed Israel in the highest category.

Key timeline data:

1952: Israel secretly founded the IAEC and placed it under the control of the Defense Ministry. See Warner D. Farr, LTC, US Army, "The Third Temple's Holy of Holies: Israel's Nuclear Weapons," *The Counterproliferation Papers*, No. 2, USAF Counterproliferation Center, Air War College (September 1999), p.2.

1953: Scientists perfected the uranium extraction process and developed a new procedure for making heavy water. See NTI.org, "Israel Profile," http://www.nti.org/e_research/profiles/Israel/Nuclear/3635_6329.html (accessed <8/8/2007>).

1956: Israel and France agreed to cooperate in the development of their nuclear weapons programs. See Warner D. Farr, LTC, US Army, “The Third Temple’s Holy of Holies: Israel’s Nuclear Weapons,” *The Counterproliferation Papers*, No. 2, USAF Counterproliferation Center, Air War College (September 1999), p.4.

1962: The Dimona reactor went critical (un-safeguarded and secured by the military). See Warner D. Farr, LTC, US Army, “The Third Temple’s Holy of Holies: Israel’s Nuclear Weapons,” *The Counterproliferation Papers*, No. 2, USAF Counterproliferation Center, Air War College (September 1999), p.9.

1964: Israeli military officials participated in the testing of French nuclear devices. See Stephen Green, *Taking Sides, America's Secret Relations with a Militant Israel* (New York: William and Morrow Company, 1984), p. 167.

1964: The plutonium processing facility became operational. See Warner D. Farr, LTC, US Army, “The Third Temple’s Holy of Holies: Israel’s Nuclear Weapons,” *The Counterproliferation Papers*, No. 2, USAF Counterproliferation Center, Air War College (September 1999), p.9.

1966: Israel was capable of producing weapons-grade fissile material, designing weapons, and testing delivery-means. See Warner D. Farr, LTC, US Army, “The Third Temple’s Holy of Holies: Israel’s Nuclear Weapons,” *The Counterproliferation Papers*, No. 2, USAF Counterproliferation Center, Air War College (September 1999), p.10.

1967: Israel assembled two nuclear bombs. See Warner D. Farr, LTC, US Army, “The Third Temple’s Holy of Holies: Israel’s Nuclear Weapons,” *The Counterproliferation Papers*, No. 2, USAF Counterproliferation Center, Air War College (September 1999), pp.10-11.

1969: The US delivered to Israel F-4E Phantom jets that were capable of delivering nuclear weapons. See Warner D. Farr, LTC, US Army, “The Third Temple’s Holy of Holies: Israel’s Nuclear Weapons,” *The Counterproliferation Papers*, No. 2, USAF Counterproliferation Center, Air War College (September 1999), p. 11.

1972: Israel developed a more efficient uranium enrichment method. See Warner D. Farr, LTC, US Army, “The Third Temple’s Holy of Holies: Israel’s Nuclear Weapons,” *The Counterproliferation Papers*, No. 2, USAF Counterproliferation Center, Air War College (September 1999), p.15.

1986: A technician formerly employed at Dimonaalleges said that Israel had more than 200 nuclear bombs, neutron bombs, F-16 deliverable warheads, and Jericho warheads. See “Revealed: The Secrets of Israel's Nuclear Arsenal" (London) *Sunday Times* No. 8,461, 5 October 1986, pp. 1, 4-5.

Status in 2007: Israel is not a member of the Nuclear Non-Proliferation Treaty. It has two nuclear research centers, a closed fuel cycle capability; and long-range delivery capabilities. See NTI.org, "Israel Profile," http://www.nti.org/e_research/profiles/Israel/Nuclear/3635_6329.html (accessed <8/8/2007>).

Libya

In 1968 Libya signed the Nuclear Non-Proliferation Treaty but in 1969 Muammar Al Qadhafi publicly expressed the desire to obtain nuclear weapons. In 1970 Qadhafi unsuccessfully approached China to buy a nuclear weapon. Despite this ambition, Libya was in the category of Nil Weapons Potential. In 1981 Libya's first research reactor (10MWt) went critical at the Tajura Nuclear Research Center, which also included a six-hot cell facility, and in 1983 small-scale uranium conversion experiments were conducted there. Libya was also receiving scientific support and training from Pakistan in the development of its nuclear program. This moved Libya into the Modest Weapons Potential category. In 1986 the US imposed additional sanctions on Libya as a result of the country's support of terrorist groups, which reduced its access to needed materials and technologies and effectively moved Libya back down into the Nil Weapons Potential category. In 1997, however, Libya imported 20 complete L-1 uranium enrichment centrifuge machines, moving it back up into the Modest Weapons Potential category. In 2000 Libya ordered 10,000 L-2 centrifuges and imported 50 kg of natural uranium. In 2002 Libya purchased drawings, designs, and fabrication documents of a 1960s Chinese implosion device. However, because Libya did not acquire an operating enrichment capability, these developments only served to solidify Libya's positioning in the Modest Weapons Potential category. An at-sea interdiction in 2003 of the BBC China discovered components for 2200+ L-2 centrifuges bound for Libya. Qadhafi subsequently renounced unconventional weapons and surrendered all of Libya's nuclear-related equipment and ballistic missiles with ranges greater than 300 km to the US These developments moved Libya back down into the Nil Weapons Potential category. As of 2007, Libya had reached an agreement for the purchase of a French nuclear power reactor for water desalination.

Key timeline data:

1968: Libya signed the Nuclear Non-Proliferation Treaty. See Joshua Sinai, "Libya's Pursuit of Weapons of Mass Destruction," *Nonproliferation Review*, Vol. 4, No. 3 (Spring/Summer 1997), p. 97.

1969: Muammar Al Qadhafi publicly expressed the desire to obtain nuclear weapons. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Libya," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/9/2007>).

1970: Qadhafi unsuccessfully approached China to buy a small nuclear weapon. See Joshua Sinai, "Libya's Pursuit of Weapons of Mass Destruction," *Nonproliferation Review*, Vol. 4, No. 3 (Spring/Summer 1997), p. 98.

1973: Libya and Pakistan formally began nuclear cooperation. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Libya," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/9/2007>).

1975: Libya ratified the NPT. See Joshua Sinai, "Libya's Pursuit of Weapons of Mass Destruction," *Nonproliferation Review*, Vol. 4, No. 3 (Spring/Summer 1997), p. 97.

1977: Libya began to help fund Pakistan's nuclear program. See Joseph Cirincione, Jon B. Wolfsthal and Miriam Rajkumar, *Deadly Arsenals Nuclear, Biological, and Chemical Threats* 2nd edition (Washington D.C.: Carnegie Endowment for International Peace, 2005), p. 321.

1980: A formal safeguards agreement with IAEA was ratified. See Scott Stinson, "Fact Sheets: Chronology of Libya's Disarmament and Relations with the United States," *Arms Control Today* (June 2005) http://www.armscontrol.org/factsheets/LibyaChronology.asp (accessed <8/9/2007>).

1981: First research reactor (10 MWt) went critical at the Tajura Nuclear Research Center. Facility includes 6 hot cells. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Libya," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/9/2007>).

1983: Small-scale uranium conversion experiments were conducted at the TNRC. Facility successfully produced UF6 and uranium metal. See Sho J. Morimoto, "Libya's Nuclear Program," http://www8.georgetown.edu/centers/cndls/applications/posterTool/index.cfm?fuseaction=poster.display&posterID=2439 (accessed <8/9/2007>).

1980s: The relationship with Pakistan atrophied. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Libya," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/9/2007>).

1986: The US imposed additional sanctions on Libya as a result of the country's support of terrorist groups. See Robert Longley, "Bush Drops Terror-Related Sanctions Against Libya," September 22, 2004, http://usgovinfo.about.com/od/defenseandsecurity/a/libyaoffhook.htm (accessed <8/21/2007>).

1997: Libya imported 20 complete L-1 uranium enrichment centrifuge machines. See Joseph Cirincione, Jon B. Wolfsthal and Miriam Rajkumar, *Deadly Arsenals Nuclear, Biological, and Chemical Threats* 2nd edition (Washington D.C.: Carnegie Endowment for International Peace, 2005), p. 322.

2000: Orders were placed for 10,000 L-2 centrifuges. Libya also imported 50 kg of uranium. See Joseph Cirincione, Jon B. Wolfsthal and Miriam Rajkumar, *Deadly Arsenals Nuclear, Biological, and Chemical Threats* 2nd edition (Washington D.C.: Carnegie Endowment for International Peace, 2005), p. 323.

2002: Drawings, designs, and fabrication documents of a 1960s-vintage Chinese implosion device were acquired from the Khan network. See Joseph Cirincione, Jon B. Wolfsthal and Miriam Rajkumar, *Deadly Arsenals Nuclear, Biological, and Chemical Threats* 2nd edition (Washington D.C.: Carnegie Endowment for International Peace, 2005), p. 323.

2003: The BBC China was intercepted, along with its cargo of components for more than 2,200 L-2 centrifuges. Qadhafi subsequently renounced unconventional weapons and surrendered nuclear-related equipment and ballistic missiles with ranges greater than 300 km to the US See Scott Stinson, "Fact Sheets: Chronology of Libya's Disarmament and Relations with the United States," *Arms Control Today* (June 2005), http://www.armscontrol.org/factsheets/LibyaChronology.asp (accessed <8/9/2007>).

2006: Libya ratified the Additional Protocol. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/9/2007>).

Status in 2007: Libya does not operate any nuclear power plants today. It maintains the Tajura research facility and operates two research reactors under IAEA safeguards. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/13/2007>).

Saudi Arabia

The Saudi timeline begins in 1975, when it began to transfer funds to the Pakistani nuclear program (at least $2 billion have been sent) and when the Nuclear Research Center was established in the military complex at Al-Suleiyel. In 1983 a cyclotron facility became operational. In 1988 Saudi Arabia acceded to the NPT. As of 2007, Saudi Arabia still does not have a safeguards agreement with the IAEA and has signed but not ratified the Additional Protocol, nor does it have an operating nuclear research or power reactor. Its relevant technical infrastructure remains underdeveloped and is inadequate to support an indigenous weapon development program. This history places Saudi Arabia in the category of Nil Weapons Potential.

Key timeline data:

1975: Saudi Arabia began to transfer funds to the Pakistani nuclear program ($2 billion sent in total). It was subsequently alleged that Saudi Arabia had made a pact with Pakistan guaranteeing that future Pakistani nuclear weapons would be used to defend Saudi Arabia against foreign aggression. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Saudi Arabia," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/9/2007>).

1975: The Nuclear Research Center was established in the military complex at Al-Suleiyel (where the kingdom now deploys the country's Chinese-supplied CSS-2 intermediate-range ballistic missiles). See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Saudi Arabia," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/9/2007>).

1980s: Saudi began to transfer massive amounts of funding to Iraq. Some reports alleged that upwards of $25 billion had been transferred, including $5 billion ear-marked for Iraq's clandestine nuclear weapons projects. See Marie Colvin, 'How an Insider Lifted the Veil on Saudi Plot for an "Islamic Bomb,"' *Sunday Times*, 24 July 1994.

1983: A cyclotron facility designed specifically for isotope production became operational. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Saudi Arabia," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/9/2007>).

1985: Saudi and Iraqi military and nuclear cooperation allegedly intensified in this period, including a pact committing Iraq to give Saudi Arabia finished weapons in exchange for continued Saudi funding. See Marie Colvin, 'How an Insider Lifted the Veil on Saudi Plot for an "Islamic Bomb,"' *Sunday Times*, 24 July 1994.

Late 1980s: The 3MV General Ionex Tandetron Accelerator (Energy Research Laboratory, King Fahd University of Petroleum and Minerals (KFUPM), Dhahran) became operational. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Saudi Arabia," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/9/2007>).

1988: Saudi Arabia purchased approximately 50 to 60 CSS-2s intermediate-range ballistic missiles from China. This missile lacks a precision guidance system and thus seems designed for mating with a nuclear, biological, or chemical warhead. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Saudi Arabia," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/9/2007>).

1988: Saudi Arabia acceded to the NPT. But it also rejected a safeguards agreement with the IAEA. In the same year, the Atomic Energy Research Institute was established. See Federation of Atomic Scientists, "Weapons of Mass Destruction: The Treaty on the Non-Proliferation of Nuclear Weapons," http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/9/2007>).

1990: The alliance between Saudi Arabia and Iraq collapsed with Iraq's invasion of Kuwait. See Marie Colvin, 'How an Insider Lifted the Veil on Saudi Plot for an "Islamic Bomb,"' *Sunday Times*, 24 July 1994.

1994: Former Saudi diplomat and nuclear physicist Mohammed Khilewi defected and provided detailed new information about past Saudi nuclear weapons development activities. See Marie Colvin, 'How an Insider Lifted the Veil on Saudi Plot for an "Islamic Bomb,"' *Sunday Times*, 24 July 1994.

1999: The Saudi defense minister visited the Kahuta Research Laboratories facility in Pakistan. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Saudi Arabia," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/9/2007>).

Status in 2007: Saudi Arabia has signed but not ratified the Additional Protocol. It has no safeguards agreement with the IAEA. But nor does it have an operating nuclear research or power reactor. It refuses to sign the Comprehensive Test-Ban Treaty. It has at best a limited technical infrastructure that is inadequate to support an indigenous weapon development program. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Saudi Arabia," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/9/2007>) and Marie Colvin, 'How an Insider Lifted the Veil on Saudi Plot for an "Islamic Bomb,"' *Sunday Times*, 24 July 1994.

South Africa

In 1952 South Africa's first uranium mining plant opened. In 1959 the Atomic Energy Board began large-scale research and development of the uranium processing process and indigenous power reactor production. This placed South Africa in the category of Nil Weapons Potential because its capabilities were still limited to research. In 1967 South Africa began its program to build peaceful nuclear explosives and started enrichment projects, constructing a laboratory-scale aerodynamic isotope separation facility. By 1970 South Africa's first uranium enrichment plant had been established. These developments moved South Africa into the Modest Weapons Potential category because its capabilities now reached the nuclear industry stage. In 1974 when South Africa's first pilot uranium enrichment plant became operational, it moved in the High Weapons Potential category. In 1978 South Africa's first nuclear device was provided with an HEU core, moving South Africa into the highest category. However, in 1990 South African President F. W. de Klerk ordered the termination of South Africa's nuclear weapons program, and in 1991 South Africa acceded to the Nuclear Non-Proliferation Treaty as a non-nuclear state. These developments moved South Africa back down a category, although it still possessed significant industrial capability. But by 1997 South Africa had ceased all uranium enrichment programs and closed the related facilities, and this moved South Africa down into the Modest Weapons Potential category. As of 2007 South Africa is rebuilding its uranium enrichment capability and becoming a global supplier of enriched uranium fuel. In addition, South Africa has been designing a new reactor, the Pebble Bed Reactor, the construction of which is set to begin in 2009.

Key timeline data:

1952: South Africa's first uranium mining plant opened. See Zondi Masiza, "A Chronology of South Africa's Nuclear Program," *Nonproliferation Review*, Vol. 1, No. 1 (Fall 1993), p. 36.

1959: Atomic Energy Board began large-scale research and development of uranium processing and indigenous power reactor production. See Zondi Masiza, "A Chronology of South Africa's Nuclear Program," *Nonproliferation Review*, Vol. 1, No. 1 (Fall 1993), p. 36.

1967: Program to build peaceful nuclear explosives began with the start of enrichment projects and construction of a laboratory-scale aerodynamic isotope separation facility. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480, September 2005

1970: First uranium enrichment plant established. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 54.

1971: Plan to explore nuclear explosives production was secretly authorized. See Zondi Masiza, "A Chronology of South Africa's Nuclear Program," *Nonproliferation Review*, Vol. 1, No. 1 (Fall 1993), p. 36.

1974: First pilot uranium enrichment plant became operational. See Zondi Masiza, "A Chronology of South Africa's Nuclear Program," *Nonproliferation Review*, Vol. 1, No. 1 (Fall 1993), p. 37.

1975: Construction began on nuclear test shafts in the Kalahari Desert. See Zondi Masiza, "A Chronology of South Africa's Nuclear Program," *Nonproliferation Review*, Vol. 1, No. 1 (Fall 1993), p. 37.

1976: First nuclear weapons test site was completed. See Zondi Masiza, "A Chronology of South Africa's Nuclear Program," *Nonproliferation Review*, Vol. 1, No. 1 (Fall 1993), p. 37.

1977: Safeguards negotiations with the IAEA regarding its uranium enrichment plant were broken off. Design and engineering work on the first gun-type device was finished. See Zondi

Masiza, "A Chronology of South Africa's Nuclear Program," *Nonproliferation Review*, Vol. 1, No. 1 (Fall 1993), pp. 37-38.

1978: Uranium enrichment plant began producing HEU. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 54

1978: The HEU core for the first nuclear device was delivered. See Zondi Masiza, "A Chronology of South Africa's Nuclear Program," *Nonproliferation Review*, Vol. 1, No. 1 (Fall 1993), p. 38.

1979: The "double flash" of light far off of the South African coastline, near the Marion Islands, was detected by the Vela reconnaissance satellite (whether the 'flash' was of nuclear origin is still unclear). See Zondi Masiza, "A Chronology of South Africa's Nuclear Program," *Nonproliferation Review*, Vol. 1, No. 1 (Fall 1993), p. 38.

1981: Armscor completed construction of a design, manufacturing, and storage facility and the first fuel fabrication facility became operational. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: South Africa," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/8/2007>).

1984: South Africa's first nuclear power plant became operational. See IAEA Research Reactor Data Base, http://www.iaea.or.at/programmes/a2/ (accessed <8/8/2007>).

1985: Development of an implosion device began. See Zondi Masiza, "A Chronology of South Africa's Nuclear Program," *Nonproliferation Review*, Vol. 1, No. 1 (Fall 1993), p. 41.

1990: President de Klerk ordered the termination of South Africa's nuclear weapons program. See Zondi Masiza, "A Chronology of South Africa's Nuclear Program," *Nonproliferation Review*, Vol. 1, No. 1 (Fall 1993), p. 45.

1991: South Africa acceded to the Nuclear Non-Proliferation Treaty. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/SouthAfrica.pdf (accessed <8/8/2007>)

1995: Enrichment facilities were permanently closed. See Joseph Cirincione, Jon B. Wolfsthal and Miriam Rajkumar, *Deadly Arsenals Nuclear, Biological, and Chemical Threats* 2nd edition (Washington D.C.: Carnegie Endowment for International Peace, 2005), pp. 411-12.

1995: Fuel fabrication plant was shut down. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: South Africa," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/8/2007>).

1997: South Africa ceased all uranium enrichment programs and closed associated facilities. See Joseph Cirincione, Jon B. Wolfsthal and Miriam Rajkumar, *Deadly Arsenals Nuclear, Biological, and Chemical Threats,* 2nd edition (Washington D.C.: Carnegie Endowment for International Peace, 2005), pp. 411-12.

1998: Conversion capability was shut down. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: South Africa," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/8/2007>).

2002: South Africa ratified the Additional Protocol. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/SouthAfrica.pdf (accessed <8/8/2007>).
Status in 2007: South Africa operates 2 nuclear power reactors and is studying the feasibility of building commercial uranium enrichment facilities. See: http://www.reachingcriticalwill.org/about/pubs/Inventory07/SouthAfrica.pdf (accessed <8/8/2007>) and http://www.businessday.co.za/articles/topstories.aspx?ID=BD4A539311.

Syria

Syria signed the NPR in 1968 and ratified it in 1969. In 1976 the Syrian Atomic Energy Commission was established. During the 1980s multiple attempts were made to purchase nuclear power reactors, but all of these deals fell through as a result of political pressures and financing difficulties. In 1990 the Nuclear Analytical Laboratory was completed. The Micro Plant Facility could serve as a prototype for a commercial-scale extraction plant. In 1991 Syria purchased a miniature neutron source reactor from China (subject to IAEA safeguards) that went critical in 1996. As of 2007 Syria has not ratified the Additional Protocol, but does have full-scope IAEA safeguards in place. Syria's nuclear program is currently at a level of limited research and development for seemingly civilian purposes. This history places Syria in the category of Nil Weapons Potential because, since the inception of its nuclear program, its capabilities have been limited to nuclear research. The events of September 2007 raise a question about the purely civilian character of Syria's nuclear ambitions. Israeli officials defended the bombing of a Syrian facility with the argument that it housed a partially constructed nuclear reactor of North Korean design, a charge denied by Syrian officials.

Key timeline data:

1968: Syria signed the NPT. See Federation of Atomic Scientists, "Weapons of Mass Destruction: The Treaty on the Non-Proliferation of Nuclear Weapons," http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/9/2007>).

1969: Completed NPT ratification. See Federation of Atomic Scientists, "Weapons of Mass Destruction: The Treaty on the Non-Proliferation of Nuclear Weapons," http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/9/2007>).

1971: The Scientific Studies Research Center was established – an "ostensibly civilian agency widely assumed to be linked to the military establishment and to be the locus of most of the research and development on unconventional weaponry and missile related technology exchanges and imports." See Federation of Atomic Scientists, "Weapons of Mass Destruction: Syria," http://www.fas.org/nuke/guide/syria/index.html (accessed <8/9/2007>).

1976: Syrian Atomic Energy Commission was established. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Syria," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/9/2007>).

1980s: Multiple attempts were made to purchase nuclear power reactors, but these all failed as a result of political pressure and financial difficulties. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Syria," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/9/2007>).

1990: The Nuclear Analytical Laboratory (NAL) was completed. A Mico Plant Facility within NAL could serve as a prototype for a commercial-scale extraction plant. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Syria," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/9/2007>).

1991: Syria purchased a miniature neutron source reactor from China (subject to IAEA safeguards). See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Syria," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/9/2007>).

1996: The mini-reactor went critical. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Syria," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/9/2007>).

1997: The Cyclotron Facility for Medical Radioisotopes was approved by the IAEA. See IAEA Technical Cooperation Database, http://www-tc.iaea.org/tcweb SYR/4/007 (accessed <8/9/2007>).

1998: Syria signed an agreement with Russia on peaceful nuclear energy use. See "Nuclear Agreement between Syria and Russia," *Science*, 20 July 1998.

Status in 2007: Syria has not ratified the Additional Protocol. But it does have full-scope IAEA safeguards in place. It operates the mini-research reactor but does not have a power reactor.

Syria's nuclear program is currently at a level of limited research and development for seemingly civilian purposes. The question of Syria's actual nuclear weapons ambitions was underscored by the Israeli Air Force strike in September 2007 against a facility in Syria allegedly containing a partially-constructed nuclear reactor of North Korean design. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Syria," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/9/2007>) and Steven Erlanger, 'Israel Silent on Reports of Bombing Within Syria,' *New York Times*, October 15, 2007.

Turkey

The Turkish Atomic Energy Commission (TAEC) was established in 1956, and in 1962 Turkey's first nuclear research reactor went critical. In 1967 the first feasibility study for the construction of a heavy-water reactor was conducted, but domestic, economic, and political developments halted the initiative. In 1980 Turkey ratified the NPT and in 2001 it ratified the Additional Protocol. As of 2007 Turkey has one operational research reactor and its nuclear program was at a level of limited research and development. This history places Turkey in the category of Nil Weapons Potential because, since the inception of its nuclear program, its capabilities have been limited to nuclear research.

Key timeline data:

1956: The TAEC was established. See Mustafa Kibaroglu, "Turkey's Quest for Peaceful Nuclear Power," *Nonproliferation Review*, Vol. 4, No. 3 (Spring/Summer 1997), p. 34.

1961: The Cekmece Nuclear Research and Training Center was established. See Mustafa Kibaroglu, "Turkey's Quest for Peaceful Nuclear Power," *Nonproliferation Review*, Vol. 4, No. 3 (Spring/Summer 1997), p. 34.

1962: Turkey's first nuclear research reactor went critical. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/9/2007>).

1966: A second nuclear training and research center was established. See Mustafa Kibaroglu, "Turkey's Quest for Peaceful Nuclear Power," *Nonproliferation Review*, Vol. 4, No. 3 (Spring/Summer 1997), p. 34.

1967: Turkey conducted its first feasibility study for the construction of a heavy-water reactor, though the initiative was halted for domestic economic and political reasons. See Mustafa Kibaroglu, "Turkey's Quest for Peaceful Nuclear Power," *Nonproliferation Review*, Vol. 4, No. 3 (Spring/Summer 1997), p. 34.

1969: Signed the NPT. See Federation of Atomic Scientists, "Weapons of Mass Destruction: The Treaty on the Non-Proliferation of Nuclear Weapons," http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/9/2007>).

1977: The first research reactor was shut down. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/9/2007>).

1979: The second research reactor went critical. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/9/2007>).

1980: Turkey ratified the NPT. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Turkey.pdf (accessed <8/9/2007>).

1981: The third research reactor went critical. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/9/2007>).

1992: A Turkish government report stated that Turkey will face an energy crisis if new energy resources are not in place by 2010. See IAEA.org, "Country Profile: Turkey," http://www.iaea.org/DataCenter/index.html (accessed <8/9/2007>).

2000: Turkey signed the Additional Protocol. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/9/2007>).

2001: Turkey ratified the Additional Protocol. See: http://www.reachingcriticalwill.org/about/pubs/Inventory07/Turkey.pdf (accessed <8/9/2007>).

Status in 2007: Turkey has one operational research reactor. Its nuclear program is currently at level of limited research and development. It faces potentially significant future energy needs. It is also host to some US nuclear weapons under the NATO nuclear sharing policy. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Turkey.pdf (accessed <8/9/2007>).

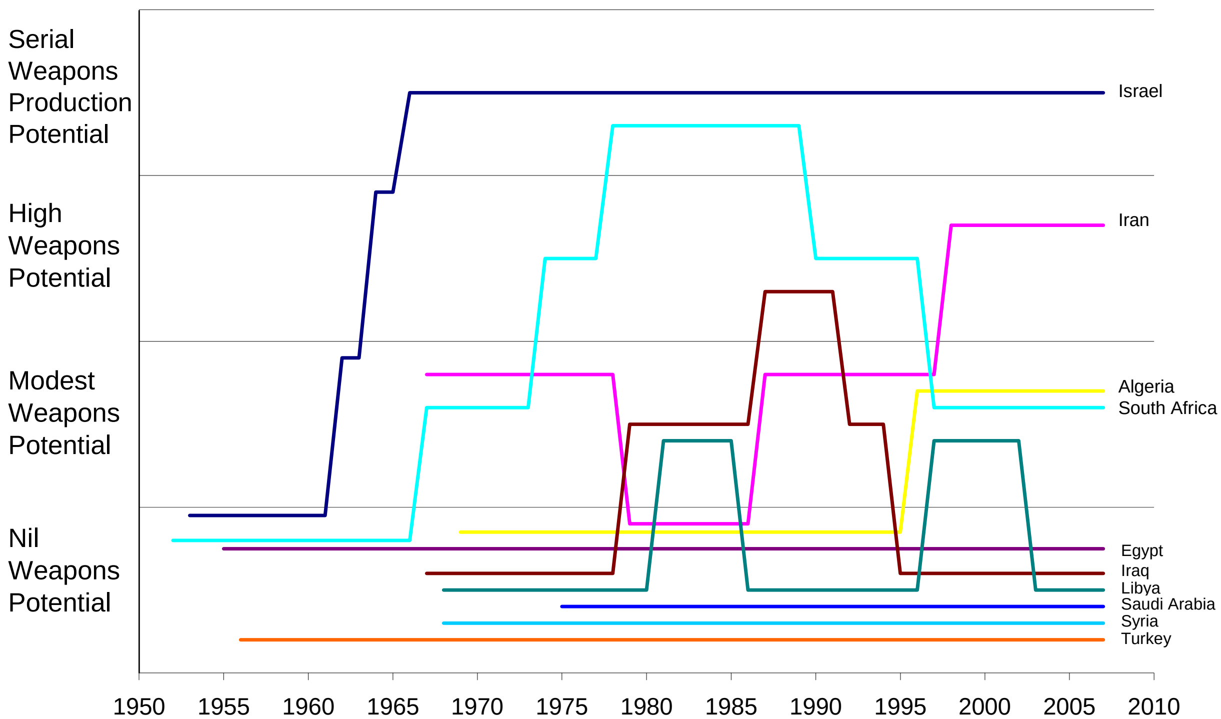

Figure 3. Nuclear Proliferation History of Middle East and Africa

D. ASIA

The nuclear history of this region encompasses the experiences of the following countries:

- Australia
- Bangladesh
- Burma
- India
- Indonesia
- Japan
- Kazakhstan
- North Korea
- Pakistan
- Philippines
- South Korea
- Taiwan
- Thailand
- Vietnam

A graphic depiction of this information appears at figure 4 at the end of this section.

<u>Australia</u>

From 1956 to 1963 Australia attempted to procure nuclear weapons directly rather than develop them indigenously. In 1956 the Defense Committee recommended that the government approach the UK for an agreement to obtain nuclear weapons. In 1958 Australia's first nuclear research reactor went critical (heavy-water moderated). These developments placed Australia in the Nil Weapons Potential category. From 1964 to 1972 Australia attempted to begin the indigenous route. In 1965 Australia's cabinet ordered a study to reexamine the indigenous nuclear option, and in 1967 Australia placed restrictions on the export of uranium so as to meet a potential future need to "pursue a military option without interference." In 1973 Australia ratified the NPT. In 1982 Australia began development of the separation of isotopes by laser excitation (SILEX) process. In 1992 the SILEX technology was proven to work on a laboratory scale. However, this development only moved Australia into the Modest Weapons Potential category because of the prohibitively inefficient nature of the SILEX enrichment process. In 1997 Australia ratified the Additional Protocol. In 2007, however, Australia's SILEX pilot plant was decommissioned, but Australia remained in the Modest Weapons Potential category because of the significant, latent scientific capability. At present Australia maintains one nuclear research reactor, but does not possess any nuclear power facilities.

Key timeline data:

[1956-1963: phase focused on efforts to procure nuclear weapons directly]

1956: The Australian Defense Committee recommended that the government approach the UK about an agreement to obtain nuclear weapons from them. See Jim Walsh, "Surprise Down Under: The Secret History of Australia's Nuclear Ambitions," *Nonproliferation Review*, Vol. 5, No.1 (Fall 1997), p. 3.

1957: The Prime Minister asked the British Air Chief and Foreign Secretary whether Britain could "supply" Australia with atomic weapons, a query also posed by the Australian Air Marshal to the British Air Chief. See Jim Walsh, "Surprise Down Under: The Secret History of Australia's Nuclear Ambitions," *Nonproliferation Review*, Vol. 5, No.1 (Fall 1997), p. 3-4.

1958: Discussions stalled over Britain's concern about the US McMahon Act. British Prime Minister Macmillan "feared that British-Australian nuclear cooperation might spook the Congress, leading it to renege on promises to loosen the law's restrictions on the sharing of nuclear information with allies." See Jim Walsh, "Surprise Down Under: The Secret History of Australia's Nuclear Ambitions," *Nonproliferation Review*, Vol. 5, No.1 (Fall 1997), p. 4.

1958: Australia's first nuclear research reactor went critical (10 MWt heavy-water moderated). See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/13/2007>).

1961: The UK requested that Australia provide the Soviet Union with listening posts as a way of revitalizing the stagnant US-Soviet negotiations on a nuclear test ban. See T.V. Paul, *Power Versus Prudence: Why States Forgo Nuclear Weapons* (Montreal: McGill-Queen's University Press, 2000), p. 75.

1961: The Australian Prime Minister requested that the UK recognize "an obligation to provide Australia, if necessary, with a nuclear capability," and the UK Prime Minister offered to lobby the US on Australia's behalf. See Jim Walsh, "Surprise Down Under: The Secret History of Australia's Nuclear Ambitions," *Nonproliferation Review*, Vol. 5, No.1 (Fall 1997), p. 7-8.

1962: Australia rejected a call by the United Nations General Assembly for all countries to renounce atomic arms. See Jim Walsh, "Surprise Down Under: The Secret History of Australia's Nuclear Ambitions," *Nonproliferation Review*, Vol. 5, No.1 (Fall 1997), p. 9.

1963: Purchased nuclear-capable FB-111 fighter bombers from the US See T.V. Paul, *Power Versus Prudence: Why States Forgo Nuclear Weapons* (Montreal: McGill-Queen's University Press, 2000), p. 75.

[1964-1972: phase focused on efforts to develop nuclear weapons indigenously]

1965: Australian cabinet ordered a study to reexamine the indigenous nuclear option. See Jim Walsh, “Surprise Down Under: The Secret History of Australia’s Nuclear Ambitions,” *Nonproliferation Review*, Vol. 5, No.1 (Fall 1997), p. 10.

1967: Restrictions were placed on the export of uranium in case Australia needed it to “pursue a military option without interference.” See Jim Walsh, “Surprise Down Under: The Secret History of Australia’s Nuclear Ambitions,” *Nonproliferation Review*, Vol. 5, No.1 (Fall 1997), p. 11.

1969: A secret nuclear cooperation agreement was signed with France. Plans began for acquisition of a reactor capable of producing plutonium. See Jim Walsh, “Surprise Down Under: The Secret History of Australia’s Nuclear Ambitions,” *Nonproliferation Review*, Vol. 5, No.1 (Fall 1997), p. 12.

1970: Australia signed the NPT. See Federation of Atomic Scientists, “Weapons on Mass Destruction: Treaty on the Non-Proliferation of Nuclear Weapons,” http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/7/2007>).

1973: Australia ratified the NPT. See Federation of Atomic Scientists, “Weapons on Mass Destruction: Treaty on the Non-Proliferation of Nuclear Weapons,” http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/7/2007>).

1982: Development of the SILEX process began (separation of isotopes by laser excitation). See M. D. Zentner, G. L. Coles, and R. J. Talbert, “Nuclear Proliferation Technology Trends Analysis,” Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 57.

1994: The SILEX technology was proven to work on a laboratory scale. See M. D. Zentner, G. L. Coles, and R. J. Talbert, “Nuclear Proliferation Technology Trends Analysis,” Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 57.

1997: Australia ratified the Additional Protocol. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

2000: SILEX Pilot Module Program and Plant was successfully completed. See IAEA Nuclear Fuel Cycle Information System, http://www-nfcis.iaea.org/NFCIS/NFCISMain.asp?RPage=1&RightP=List (accessed <3/2/2008>).

2006: 2nd research reactor (20 MWt) operational. See ANSTO staff. "HIFAR Media Backgrounder", *ANSTO Media Releases*, Australian Nuclear Science and Technology Organisation, http://www.ansto.gov.au/ (accessed <3/2/2008>).

2007: SILEX pilot plant was decommissioned. See IAEA Nuclear Fuel Cycle Information System, http://www-nfcis.iaea.org/NFCIS/NFCISMain.asp?RPage=1&RightP=List (accessed <3/2/2008>).

Status in 2007: Australia maintains one nuclear research reactor. It has no nuclear power facilities. Its uranium reserves are the world's largest. See: http://www.reachingcriticalwill.org/about/pubs/Inventory07/Australia.pdf (accessed <8/13/2007>).

Bangladesh

Bangladesh acceded to the NPT in 1979. In 1986 its first nuclear research reactor became operational (TRIGA Mark II, under IAEA safeguards). In 2001 Bangladesh ratified the Additional Protocol. As of 2007 Bangladesh is also interested in building a 300 MWe PWR plant. This history places Bangladesh in the category of Nil Weapons Potential because its nuclear program its capabilities have been limited to nuclear research.

Key timeline data:

1979: Acceded to the NPT.

1986: The first nuclear research reactor became operational under IAEA safeguards—the TRIGA Mark II.

2000: Ratified the CTBT.

2001: Ratified the Additional Protocol.

Status in 2007: Expressed interest in building a 300 MWe power plant.

See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Bangladesh.pdf (accessed <8/7/2007>), and IAEA Research Reactor Data Base http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/8/2007>).

Burma

Burma ratified the NPT in 1970 and in 1982 its first nuclear research reactor went critical. As of 2007 Burma has signed but not ratified the Additional Protocol. It has also reached a deal with Russia to buy a 10 MWt light-water reactor, an activation analysis laboratory, a medical isotope production laboratory, a silicon doping system, and a nuclear waste treatment and burial facility—and to have 300-350 specialists trained by Russian technicians. This history places Burma in the category of Nil Weapons Potential because its capabilities have been limited to nuclear research.

Key timeline data:

1970: Ratified the NPT.

1982: Nuclear research reactor went critical.

Status in 2007: Burma has signed but not ratified the Additional Protocol. Following an agreement with Russia, it will acquire the capabilities noted above.

See Federation of Atomic Scientists, "Weapons on Mass Destruction: Treaty on the Non-Proliferation of Nuclear Weapons," http://www./nuke/control/npt/text/npt3.htm (accessed <8/8/2007>), IAEA Research Reactor Data Base http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/8/2007>), and "Russia and Burma in Nuclear Deal," *BBC News*, May, 15, 2007, http://news.bbc.co.uk/go/pr/fr/-/2/hi/asia-pacific/6658713.stm (accessed <5/20/2007>).

India

India's first research reactor went critical in 1956. In 1958 a plan was initiated to build a spent fuel reprocessing plant. This placed India in the category of Nil Weapons Potential because its capabilities were still limited to research. In 1959 the Fuel Element Fabrication Facility was completed, and in 1960 a Canadian-supplied heavy water research reactor went critical. These developments moved India into the Modest Weapons Potential category. In 1964 a plutonium reprocessing/separation plant became operational and the Indian Prime Minister approved plans for a subterranean nuclear explosion project (SNEP). In 1968 scientists were ordered to start work on designing a nuclear explosive device that would utilize plutonium. As these efforts matured, India had moved into the High Weapons Potential category by 1970. In 1972 the Indian Prime Minister approved a nuclear explosive device experiment, and in 1974 India's first nuclear explosion occurred. These developments moved India into the Potential for Serial Weapons Production category. In more recent developments, India and the US held a summit in Washington in July 2005 to discuss civilian nuclear cooperation. In 2006 the United States-India Peaceful Atomic Energy Act came into being, establishing the legal framework for a bilateral pact between the US and India under which the US will provide India with access to civilian nuclear technology and nuclear fuel in exchange for IAEA-safeguards on civilian Indian reactors. Both the US Congress and the Indian Cabinet, however, have to approve this agreement before it can be implemented. Currently, it does not seem likely that India's cabinet will approve this agreement and US congressional approval also does not seem to be guaranteed. Importantly, if the agreement is implemented it would greatly increase India's access to fissile material. As of 2007 India is not a signatory of the NPT and has not ratified the Additional Protocol.

Key timeline data:

1956: India's first research reactor went critical. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/9/2007>).

1958: Project Phoenix was initiated—a plan to build a spent fuel reprocessing plant. See Joseph Cirincione, Jon B. Wolfsthal and Miriam Rajkumar, *Deadly Arsenals Nuclear, Biological, and Chemical Threats,* 2nd edition (Washington D.C.: Carnegie Endowment for International Peace, 2005), p. 225.

1959: A fuel element fabrication facility was completed. See IAEA.org, "Country Profile: India," http://www.iaea.org/DataCenter/index.html (accessed <8/9/2007>).

1960: A Canadian-supplied heavy water research reactor went critical (CANDU, 40MWt). See IAEA.org, "Country Profile: India," http://www.iaea.org/DataCenter/index.html (accessed <8/9/2007>).

1962: A uranium ore processing plant became operational. See NTI.org, "India Profile," http://www.nti.org/e_research/profiles/India/Nuclear/2296_2346.html (accessed <8/9/2007>).

1964: A plant for separating and reprocessing plutonium became operational and the Prime Minister approved a plan for a SNEP. See NTI.org, "India Profile," http://www.nti.org/e_research/profiles/India/Nuclear/2296_2346.html (accessed <8/9/2007>).

1966: The head of the Department of Atomic Energy Commission (AEC) halted the SNEP, and the Indian government chose to focus on peaceful nuclear energy development. See George Perkovich, *India's Nuclear Bomb: The Impact on Global Proliferation* (Berkeley, CA: University of California Press, 1999), p. 122.

1968: AEC commenced work on designing a nuclear explosive device (plutonium). See George Perkovich, *India's Nuclear Bomb: The Impact on Global Proliferation* (Berkeley, CA: University of California Press, 1999), p. 141.

1968: The Indian parliament vetoed accession to the Nuclear Non-Proliferation Treaty. See George Perkovich, *India's Nuclear Bomb: The Impact on Global Proliferation* (Berkeley, CA: University of California Press, 1999), p. 125.

1970: The head of the AEC called for the development of "atomic energy and space research" of a 10-year period. See George Perkovich, *India's Nuclear Bomb: The Impact on Global Proliferation* (Berkeley, CA: University of California Press, 1999), p. 152.

1972: The Indian prime minister approved a nuclear explosive device experiment. See George Perkovich, *India's Nuclear Bomb: The Impact on Global Proliferation* (Berkeley, CA: University of California Press, 1999), p. 172.

1974: The "peaceful" nuclear explosion was conducted. See Joseph Cirincione, Jon B. Wolfsthal and Miriam Rajkumar, *Deadly Arsenals Nuclear, Biological, and Chemical Threats,* 2nd edition (Washington D.C.: Carnegie Endowment for International Peace, 2005), p. 225.

1998: India conducted five nuclear tests in May. See Joseph Cirincione, Jon B. Wolfsthal, and Miriam Rajkumar, *Deadly Arsenals Nuclear, Biological, and Chemical Threats,* 2nd edition (Washington D.C.: Carnegie Endowment for International Peace, 2005), p. 225.

Status in 2007: India is has a closed fuel cycle capability. Only 4 of its 17 nuclear reactors are subject to IAEA safeguards. It is not a signatory of the NPT or the CTBT and has not accepted the Additional Protocol. Presently developing an ICBM. See Joseph Cirincione, Jon B. Wolfsthal and Miriam Rajkumar, *Deadly Arsenals Nuclear, Biological, and Chemical Threats,* 2nd edition (Washington D.C.: Carnegie Endowment for International Peace, 2005), pp. 221-237.

Indonesia

The state Commission of Radioactivity and Atomic Energy was established in 1954. In 1961 Indonesia began constructing its first nuclear research facility, with US assistance, and in 1964 its first research reactor went critical. This placed Indonesia in the category of Nil Weapons Potential. In 1965 President Sukarno publicly declared his support for an Indonesian nuclear weapon. In 1966 General Suharto formally agreed to international safeguards of sensitive nuclear materials and equipment received from the US. In 1979 Indonesia ratified the NPT. Also in that year its second research reactor went critical. In 1981 Indonesia developed a laboratory-scale fuel fabrication capability and in 1985 a laboratory-scale uranium ore processing capability, developments that moved Indonesia into the Modest Weapons Potential category. In 1999 Indonesia ratified the Additional Protocol. At present Indonesia maintains three research reactors and possesses a laboratory-scale open fuel cycle capability.

Key timeline data:

1954: The State Commission of Radioactivity and Atomic Energy was established. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Indonesia," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/10/2007>).

1958: The Foreign Minister stated that Indonesia had no interest in heading in the direction of nuclear weapons. See Robert M. Cornejo, "When Sukarno Sought the Bomb: Indonesian Nuclear Aspirations in the Mid-1960s," *Nonproliferation Review*, Vol. 7, No. 2 (Summer 2000), p. 32.

1961: With US assistance, Indonesia began constructing its first nuclear research facility,. See Robert M. Cornejo, "When Sukarno Sought the Bomb: Indonesian Nuclear Aspirations in the Mid-1960s," *Nonproliferation Review*, Vol. 7, No. 2 (Summer 2000), p. 32.

1964: The first research reactor (250 kW TRIGA-Mark II) went critical. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/10/2007>).

1965: President Sukarno publicly declared his support for an Indonesian nuclear weapon and Soviet assistance was significantly increased. See Robert M. Cornejo, "When Sukarno Sought the Bomb: Indonesian Nuclear Aspirations in the Mid-1960s," *Nonproliferation Review*, Vol. 7, No. 2 (Summer 2000), p. 32-7.

1965: The DiReactor of Army Ordnance Department, Brigadier General Hartono, stated that 200 Indonesian scientists were conducting tests on the production of an atom bomb. China and Indonesia agreed to strengthen technical cooperation, although the Chinese Foreign Minister stated that the request for China's help in the manufacture of atomic bombs was not realistic. See Robert M. Cornejo, "When Sukarno Sought the Bomb: Indonesian Nuclear Aspirations in the Mid-1960s," *Nonproliferation Review*, Vol. 7, No. 2 (Summer 2000), pp. 35 and 37.

1966: President Sukarno transferred power to General Suharto. See Robert M. Cornejo, "When Sukarno Sought the Bomb: Indonesian Nuclear Aspirations in the Mid-1960s," *Nonproliferation Review*, Vol. 7, No. 2 (Summer 2000), p. 38.

1967: Suharto's government formally agreed to international safeguards of sensitive nuclear materials and equipment received from the US See Robert M. Cornejo, "When Sukarno Sought the Bomb: Indonesian Nuclear Aspirations in the Mid-1960s," *Nonproliferation Review*, Vol. 7, No. 2 (Summer 2000), p. 38.

1979: Indonesia ratified the NPT, and its second research reactor went critical. See IAEA.org, "Country Profile: Indonesia," http://www.iaea.org/DataCenter/index.html (accessed <8/10/2007>).

1980: A comprehensive safeguards agreement with the IAEA was ratified. See IAEA.org, "Country Profile: Indonesia," http://www.iaea.org/DataCenter/index.html (accessed <8/10/2007>).

1981: A laboratory-scale fuel fabrication capability was developed. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Indonesia," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/10/2007>).

1985: A laboratory-scale uranium ore processing capability was developed. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Indonesia," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/10/2007>).

1991: A laboratory-scale uranium conversion research facility became operational. See Stockholm International Peace Research Institute.org, "Countries and Issues of Nuclear Strategic Concern: Indonesia," http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/10/2007>).

1999: Indonesia ratified the Additional Protocol. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/10/2007>).

Status in 2007: Indonesia maintains 3 research reactors and has a laboratory-scale open fuel cycle capability. It also has plans to build up to 12 nuclear power units by 2016. It has signed but not ratified the CTBT. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Indonesia.pdf (accessed <8/10/2007>).

Japan

Japan began the domestic development of uranium enrichment technology in 1959. Its first nuclear research reactor went critical in 1961. This placed Japan in the Nil Weapons Potential category. In 1965 Japan's first nuclear power reactor went critical, moving Japan into the Modest Weapons Potential category. In 1969 Japan conducted its first successful test of uranium enrichment, using the centrifugal separation method. This development moved Japan into the High Weapons Potential category. In 1976 Japan ratified the NPT. Also in that year it began a full-scale centrifuge uranium enrichment program. In 1999 Japan ratified the Additional Protocol. As of 2007 Japan has 53 nuclear power reactors and a closed nuclear fuel cycle capability.

Key timeline data:

1954: Japan's leaders elaborated the Yoshida doctrine, which gave priority to Japan's domestic economy and reconstruction. See T.V. Paul, *Power Versus Prudence: Why States Forgo Nuclear Weapons* (Montreal: McGill-Queen's University Press, 2000), p. 48.

1959: Domestic development of uranium enrichment technology began. See *Country Nuclear Fuel Cycle Profiles*, 2nd edition, International Atomic Energy Agency, Technical Reports Series No. 425 (Vienna: IAEA, 2005), p. 51.

1961: Japan's first nuclear research reactor went critical. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/10/2007>).

1964: In response to China's nuclear test, some Japanese leaders called for a reexamination of the policy of nuclear abstention. See Motoya Kitamura, "Japan's Plutonium Program: A Proliferation Threat?," *Nonproliferation Review*, Vol. 3, No.2 (Winter 1996), p. 6.

1965: Japan's first nuclear power reactor went critical. See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/10/2007>).

1967: Japan's leaders endorsed the Three Non-Nuclear Principles, which commit Japan not "to possess or manufacture nuclear weapons or to allow them to be introduced into the nation." Japan also announced the Long Term Program for developing a closed nuclear fuel cycle through uranium enrichment and plutonium reprocessing. See Motoya Kitamura, "Japan's Plutonium Program: A Proliferation Threat?," *Nonproliferation Review*, Vol. 3, No.2 (Winter 1996), p. 2.

1969: The first successful test of uranium enrichment using the centrifugal separation method was completed. See Japan Nuclear Cycle Development Institute, "Brief History of JNC," http://www.jaea.go.jp/jnc/jncweb/ (accessed <8/10/2007>).

1970: Japan signed the NPT. See Federation of Atomic Scientists, "Weapons of Mass Destruction: The Treaty on the Non-Proliferation of Nuclear Weapons," http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/10/2007>).

1972: An EMIS uranium enrichment program was initiated. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 41.

1976: Japan ratified the NPT. See T.V. Paul, *Power Versus Prudence: Why States Forgo Nuclear Weapons* (Montreal: McGill-Queen's University Press, 2000), p. 50.

1976: A full-scale centrifuge uranium enrichment program began. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 23.

1977: An experimental fast breeder reactor went critical. See Motoya Kitamura, "Japan's Plutonium Program: A Proliferation Threat?," *Nonproliferation Review*, Vol. 3, No.2 (Winter 1996), p. 2.

1979: The first uranium enrichment demonstration facility became operational, along with the first EMIS enrichment demonstration facility. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), pp. 23, 45-46.

1999: Japan ratified the Additional Protocol. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/10/2007>).

Status in 2007: Japan has a closed nuclear fuel cycle capability supporting 53 nuclear power reactors. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Japan.pdf (accessed <8/10/2007).

Kazakhstan

With the collapse of the Soviet Union in 1991, Kazakhstan inherited approximately 1,410 nuclear warheads and the Semipalatinsk nuclear weapons test site. This placed Kazakhstan in the Potential for Serial Weapons Production category. In 1993, however, Kazakhstan acceded to the NPT, and by 1995 the last strategic nuclear weapons had been removed from its territory and the Semipalatinsk test facility had been completely shutdown. These developments moved Kazakhstan down into the Modest Weapons Potential category. By 1999, Kazakhstan's only nuclear unit in operation, Aktau, a breeder reactor, had been shutdown. Kazakhstan ratified the Additional Protocol in 2007; however, it remains in the Modest Weapons Potential category because breeder reactors are not very proliferation resistant and 3 MT of plutonium are still in the shutdown reactor at Aktau.

Key timeline data:

1991: With the collapse of the Soviet Union, Kazakhstan inherited approximately 1,410 nuclear warheads and the Semipalatinsk nuclear weapons test site. See Mark D. Skootsky, "An Annotated Chronology of Post-Soviet Nuclear Disarmament 1991-1994," *Nonproliferation Review*, Vol. 2, No. 3 (Summer/Spring 1995), p. 64.

1992: Kazakhstan signed the Lisbon Protocol, committing it to relinquish the inherited weapons. It also ratified START I. See Mark D. Skootsky, "An Annotated Chronology of Post-Soviet Nuclear Disarmament 1991-1994," *Nonproliferation Review*, Vol. 2, No. 3 (Summer/Spring 1995), p. 70.

1993: Kazakhstan acceded to the NPT. See Federation of Atomic Scientists, "Weapons of Mass Destruction: The Treaty on the Non-Proliferation of Nuclear Weapons," http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/10/2007>).

1994: In partnership with the US under Project Sapphire, 581 kg of HEU were airlifted to the US. An agreement was also reached establishing a 14-month timetable for the transfer of all nuclear warheads to Russia. See Mark D. Skootsky, "An Annotated Chronology of Post-Soviet Nuclear Disarmament 1991-1994," *Nonproliferation Review*, Vol. 2, No. 3 (Summer/Spring 1995), p. 96.

1994: Kazakhstan ratified the NPT. See Federation of Atomic Scientists, “Weapons of Mass Destruction: The Treaty on the Non-Proliferation of Nuclear Weapons,” http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/10/2007>).

1995: The last strategic nuclear weapons were removed. A comprehensive safeguards agreement with IAEA was ratified. The Semipalatinsk test facility was closed. See Stockholm International Peace Research Institute.org, “Countries and Issues of Nuclear Strategic Concern: Kazakhstan,” http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/10/2007>).

1999: The remaining nuclear unit, a breeder reactor (Aktau), was shut down. See Stockholm International Peace Research Institute.org, “Countries and Issues of Nuclear Strategic Concern: Kazakhstan,” http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/10/2007>).

2006: Kazakhstan signed a treaty establishing a Central Asian Nuclear Weapons Free Zone. See Sonia Luthra, “Central Asian States Renounce Nuclear Weapons,” *Arms Control Today*, Vol. 36, No. 8 (October 2006).

Status in 2007: Kazakstan possesses 3 MT of plutonium in shut-down breeder reactor at Aktau but has signed and ratified the Additional Protocol. See Stockholm International Peace Research Institute.org, “Countries and Issues of Nuclear Strategic Concern: Kazakhstan,” http://www.sipri.org/contents/expcon/cnscindex.html (accessed <8/10/2007>).

North Korea

The North Korean nuclear program began in the 1950s. Its first research reactor—the 5MW(e) at Yongbyon—went critical in 1965. This placed North Korea in the category of Nil Weapons Potential because its capabilities were still limited to research. In 1985 North Korea acceded to the NPT and thereafter began IAEA safeguards negotiations. At the same time, construction began on a plutonium reprocessing facility. In 1987 the second Yongbyon reactor, 20 MW(e), went critical. These two developments combined to move North Korea into the Modest Weapons Potential category by 1987. In 1989 North Korea shut down its main research reactor and removed the fuel rods for reprocessing. Construction of the plutonium reprocessing facility, the Radiochemical Laboratory, was quickly completed, and it became operational in 1993. In 1995 it began a secret enrichment program, allegedly with assistance from Pakistan. The development of a cache of fissile material during this period moved North Korea into the High Weapons Potential category. In 2003 North Korea announced its withdrawal from the NPT and restarted its plutonium-reprocessing facility. In 2006 North Korea conducted its first explosive nuclear test. These developments moved North Korea into the Potential for Serial Weapons Production category. As of 2007, however, within the framework of the Six-Party Talks, North Korea had ceased its production of plutonium and was working toward an agreement on the declaration and dismantlement of all of its nuclear facilities.

Key timeline data:

1950s: Nuclear program began. See GlobalSecurity.org "Weapons of Mass Destruction: North Korea," http://www.globalsecurity.org/wmd/world/dprk/nuke.htm (accessed <8/9/2007>).

1965: North Korea's first nuclear research reactor went critical—the 5MW(e) unit at Yongbyon. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/9/2007>).

1980: Construction began on a natural uranium-graphite reactor. See NTI.org, "North Korea Profile," http://www.nti.org/e_research/profiles/NK/Nuclear/46_89.html (accessed <8/9/2007>).

1985: North Korea acceded to the Nuclear Non-Proliferation Treaty and thereafter began IAEA safeguards negotiations. It also began construction on a plutonium reprocessing facility. See Joseph Cirincione, Jon B. Wolfsthal, and Miriam Rajkumar, *Deadly Arsenals Nuclear, Biological, and Chemical Threats,* 2nd edition (Washington D.C.: Carnegie Endowment for International Peace, 2005), p. 285.

1987: The second Yongbyon reactor (20 MW(e)) went critical. See Larry A. Niksch, *North Korea's Nuclear Weapons Program*, CRS Report IB91141 (Washington D.C.: Congressional Research Service, 2003), p. 6.

1989: The main research reactor was shut down and the fuel rods were removed for reprocessing. See John Fialka, "North Korea May Be Developing Ability to Produce Nuclear Weapons," *Wall Street Journal*, July 19, 1989.

1990: A radiochemical laboratory for materials processing underwent test runs. M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 96.

1992: North Korea approved its IAEA safeguards agreement. See Joseph Cirincione, Jon B. Wolfsthal, and Miriam Rajkumar, *Deadly Arsenals Nuclear, Biological, and Chemical Threats,* 2nd edition (Washington D.C.: Carnegie Endowment for International Peace, 2005), p. 285.

1993: Facility for plutonium reprocessing, the Radiochemical Laboratory, became operational. See IAEA Nuclear Fuel Cycle Information System, http://www-nfcis.iaea.org/NFCIS/NFCISMain.asp?RPage=1&RightP=List (accessed <3/2/2008>).

1993: The IAEA declared it could not certify that North Korea was not using its nuclear program for weapons purposes. See Joseph Cirincione, Jon B. Wolfsthal and Miriam Rajkumar, *Deadly Arsenals Nuclear, Biological, and Chemical Threats* 2nd edition (Washington D.C.: Carnegie Endowment for International Peace, 2005), p. 286.

1994: The United States and North Korea reached an agreement to suspend North Korea's nuclear program (the "Agreed Framework"). See Larry A. Niksch, *North Korea's Nuclear Weapons Program*, CRS Report IB91141 (Washington D.C.: Congressional Research Service, 2003), p. 6.

1995: North Korea began a secret enrichment program, allegedly with assistance from Pakistan. See Larry A. Niksch, *North Korea's Nuclear Weapons Program*, CRS Report IB91141 (Washington D.C.: Congressional Research Service, 2003), p. 1.

2002: IAEA inspectors were expelled, seals were removed, and reactors were restarted. See Larry A. Niksch, *North Korea's Nuclear Weapons Program*, CRS Report IB91141 (Washington D.C.: Congressional Research Service, 2003), p. 2.

2003: North Korea announced its immediate withdrawal from the NPT. See Larry A. Niksch, *North Korea's Nuclear Weapons Program*, CRS Report IB91141 (Washington D.C.: Congressional Research Service, 2003), p. 2.

2003: The plutonium-reprocessing facility was restarted. See David Albright and Paul Brannan, "The North Korean Plutonium Stock," *International for Science and International Security* Document (February 20, 2007), p. 3, http://www.isis-online.org/publications/dprk/DPRKplutoniumFEB.pdf (accessed <8/9/2007>).

2006: The first nuclear explosives test was conducted. See Federation of Atomic Scientists, "Weapons of Mass Destruction: The Democratic Peoples Republic of Korea," http://www.fas.org/nuke/guide/dprk/nuke/index.html (accessed <8/9/2007>).

Status in 2007: North Korea has a closed fuel cycle capability. It possesses an atomic reactor with a capacity of 5MWe and two larger reactors are under construction (estimated 50 MWe and 200 MWe). It is negotiating the dismantlement of its program. It withdrew from the NPT after it was found in violation of its commitments and has not signed the CTBT or ratified the Additional Protocol. North Korea also has a medium-range ballistic missile capability and is developing both intermediate and intercontinental-range ballistic missiles. See: http://www.reachingcriticalwill.org/about/pubs/Inventory07/DPRK.pdf (accessed <8/9/2007>).

Pakistan

The Pakistan Atomic Energy Commission (PAEC) was established in 1957 and was under direct military control by 1958. Pakistan's first research reactor went critical in 1965, under IAEA safeguards, moving Pakistan into the Nil Weapons Potential category. In 1971, Pakistan moved into the Modest Weapons Potential category when a CANDU heavy-water power reactor went critical (under IAEA safeguards). In 1972 Prime Minister Ali Bhutto authorized a nuclear weapons program. By 1973 construction was complete on a Belgian-supplied pilot plutonium separation facility, which utilized PUREX technology and was capable of extracting 15 kg Pu/yr. In 1974 work was initiated on an atomic bomb design. In 1975 Pakistan began purchasing uranium enrichment equipment. In 1980 the first uranium enrichment demonstration facility became operational at the Kahuta Research Laboratories (KRL). This development moved Pakistan into the High Weapons Potential category. By 1988 Pakistan had acquired the ability to assemble a nuclear device, moving Pakistan into the Potential for Serial Weapons Production category. In 1998 Pakistan conducted its first nuclear tests and claimed that six bombs were detonated in total, five sub-kiloton nuclear devices and one boosted fission device. As of 2007 Pakistan is not a signatory of the NPT and has not ratified the Additional Protocol.

Key timeline data:

1957: The Pakistan Atomic Energy Commission (PAEC) was established. See Samina Ahmed, "Pakistan's Nuclear Weapons Program: Turning Points and Nuclear Choices, *International Security*, Vol. 24, No. 3 (Spring 1999), p. 181.

1958: The PAEC was put under direct military control. See Samina Ahmed, "Pakistan's Nuclear Weapons Program: Turning Points and Nuclear Choices, *International Security*, Vol. 24, No. 3 (Spring 1999), p. 181.

1965: The first research reactor went critical (under IAEA safeguards). See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/10/2007>).

1968: Pakistan declined to sign the NPT. See Samina Ahmed, "Pakistan's Nuclear Weapons Program: Turning Points and Nuclear Choices, *International Security*, Vol. 24, No. 3 (Spring 1999), p. 183.

1971: The CANDU reactor went critical (under IAEA safeguards). See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/10/2007>).

1972: Prime Minister Ali Bhutto authorized a nuclear weapons program. See Joseph Cirincione, Jon B. Wolfsthal and Miriam Rajkumar, *Deadly Arsenals Nuclear, Biological, and Chemical Threat,s* 2nd edition (Washington D.C.: Carnegie Endowment for International Peace, 2005), p. 243.

1973: Construction was completed a on Belgian-supplied pilot plutonium separation facility, which utilized PUREX technology and was capable of extracting 15 kg Pu/yr. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 97.

1974: Pakistan initiated design work on an atomic bomb. See Samina Ahmed, "Pakistan's Nuclear Weapons Program: Turning Points and Nuclear Choices, *International Security*, Vol. 24, No. 3 (Spring 1999), p. 184.

1975: Pakistan began purchasing uranium enrichment equipment. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 24.

1976: Kahuta Research Laboratories (KRL) was established and given the exclusive task of the indigenous development of the Uranium Enrichment Plant. See Samina Ahmed, "Pakistan's Nuclear Weapons Program: Turning Points and Nuclear Choices, *International Security*, Vol. 24, No. 3 (Spring 1999), p. 184.

1980: Pakistan's first uranium enrichment demonstration facility became operational at KRL. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 20.

1981: Nuclear weapons test shafts were completed in preparation for a suspected nuclear test. See NTI.org, "Pakistan Profile," http://www.nti.org/e_research/profiles/Pakistan/Nuclear/5593_5952.html (accessed <8/10/2007>).

1983: Pakistan conducted its first "cold tests" of weapon design (implosion). See Samina Ahmed, "Pakistan's Nuclear Weapons Program: Turning Points and Nuclear Choices, *International Security*, Vol. 24, No. 3 (Spring 1999), p. 187.

1984: First full-scale uranium enrichment facility became operational. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 25.

1986: Chashma fuel fabrication facility became operational. See *Country Nuclear Fuel Cycle Profiles*, 2nd edition, International Atomic Energy Agency, Technical Reports Series No. 425 (Vienna: IAEA, 2005), p. 65.

1988: Capabilities were in place to assemble a nuclear device. See Samina Ahmed, "Pakistan's Nuclear Weapons Program: Turning Points and Nuclear Choices, *International Security*, Vol. 24, No. 3 (Spring 1999), p. 188.

Mid-1990s: Capability of pilot plutonium reprocessing facility was expanded. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 97.

1998: Pakistan conducted its first nuclear tests and claimed that six bombs were detonated in total (five sub-kiloton nuclear devices and one boosted fission device). A Chinese-supplied heavy-water 40 MWt reactor also became operational, although heavy-water supplies were not available. See Federation of Atomic Scientists, "Weapons on Mass Destruction: Pakistan," http://www.fas.org/nuke/guide/pakistan/nuke/index.html (accessed <8/10/2007>).

1998: Attempts were made to acquire AVLIS equipment in Europe. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 59.

Status in 2007: Pakistan has a closed fuel cycle capability and an infrastructure for weapons production. It also has a medium-range ballistic missile capability and is developing intermediate-range ballistic missiles. It is not a signatory of the NPT or CTBT and has not ratified the Additional Protocol. See Federation of Atomic Scientists, "Weapons on Mass Destruction: Pakistan," http://www.fas.org/nuke/guide/pakistan/nuke/index.html (accessed <8/10/2007>).

Philippines

The Philippines' first research reactor went critical in 1963, subject to IAEA safeguards. The Philippines ratified the NPT in 1972. In 1988 it shut down its one research reactor. As of 2007 the Philippines has signed but not ratified the Additional Protocol and possesses one shut down research reactor. This history places the Philippines in the category of Nil Weapons Potential because, since the inception of its nuclear program, its capabilities have been limited to nuclear research.

Key timeline data:

1963: First research reactor went critical (subject to IAEA safeguards).

1972: NPT ratified.

1988: Research reactor shut down.

Status in 2007: The Philippines possesses only one non-functioning research reactor. It has signed but not ratified the Additional Protocol. See Federation of Atomic Scientists, "Weapons on Mass Destruction: Treaty on the Non-Proliferation of Nuclear Weapons," http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/8/2007>), and IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/8/2007>).

South Korea

South Korea established the Office of Atomic Energy in 1959 and its first nuclear research reactor went critical in 1962. This placed South Korea in the Nil Weapons Potential category. In 1970 South Korea created the Weapons Exploitation Committee, which recommended the development of a nuclear weapons capability. South Korea also began construction on a light water reactor and initiated a clandestine nuclear weapons research effort. In 1975 South Korea ratified the NPT and a comprehensive safeguards agreement with the IAEA, and in 1977 South Korea's first nuclear power reactor went critical. These developments moved South Korea into the Modest Weapons Potential category. However, in 1979 chemical enrichment experiments began (undeclared and un-safeguarded until 2004), moving South Korea into the High Weapons Potential category. In 1981 the chemical enrichment experiments ended, moving South Korea back down to the Modest Weapons Potential category. In 1991 South Korea began AVLIS enrichment experiments (un-safeguarded/undeclared until 2004), moving South Korea back up into the High Weapons Potential category. By 2000 the AVLIS uranium enrichment experiments ended, moving South Korea back down to the Modest Weapons Potential category. In 2004 South Korea ratified the Additional Protocol and declared past enrichment and separation experiments. Presently, South Korea maintains 20 nuclear power units with 8 more planned or under construction, and the Korean Atomic Research Institute (KAERI) has developed both pressurized water reactor (PWR) and CANDU fuel technology.

Key timeline data:

1959: Office of Atomic Energy was established. See IAEA.org, "Country Profile: South Korea," http://www.iaea.org/DataCenter/index.html (accessed <8/10/2007>).

1962: First nuclear research reactor went critical. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/10/2007>).

1970: The Weapons Exploitation Committee was created and recommended the development of a nuclear weapons capability. A clandestine research effort and construction of a light water reactor began. See Jungmin Kang and H. A. Feiveson, "South Korea's Shifting and Controversial Interest in Spent Fuel Reprocessing," *Nonproliferation Review*, Vol. 8, No. 1 (Spring 2001), p.71.

1975: South Korea contracted with a French company to provide a plutonium reprocessing plant. See Rebecca K.C. Hersman and Robert Peters, "Nuclear U-Turns: Learning from the South Korean and Taiwanese Rollback," *Nonproliferation Review*, Vol. 13, No. 3 (November 2006), p.541.

1975: The NPT was ratified as was a comprehensive safeguards agreement with the IAEA. See IAEA.org, "Country Profile: South Korea," http://www.iaea.org/DataCenter/index.html (accessed <8/10/2007>).

1976: Under pressure from the US, South Korea ended negotiations with France for the reprocessing plant. But South Korea continued to engage in modest weapons-related research and to modernize its nuclear power industry. See Jungmin Kang and H. A. Feiveson, "South Korea's Shifting and Controversial Interest in Spent Fuel Reprocessing," *Nonproliferation Review*, Vol. 8, No. 1 (Spring 2001), p.71.

1977: First nuclear power reactor went critical. See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/23/2007>).

1979: Chemical enrichment experiments began (un-safeguarded/undeclared until 2004). See Jungmin Kang, Peter Hays, Li Bin, Tatsujiro Suzuki, and Richard Tanter, "South Korea's Nuclear Surprise," *Bulletin of the Atomic Scientists*, Vol. 61, No. 1 (January/February 2005), p. 40.

1981: The chemical enrichment experiments concluded. See Jungmin Kang, Peter Hays, Li Bin, Tatsujiro Suzuki and Richard Tanter, "South Korea's Nuclear Surprise," *Bulletin of the Atomic Scientists*, Vol. 61, No. 1 (January/February 2005), p. 40.

1982: Plutonium separation and uranium conversion experiments began. See Jungmin Kang, Peter Hays, Li Bin, Tatsujiro Suzuki, and Richard Tanter, "South Korea's Nuclear Surprise," *Bulletin of the Atomic Scientists*, Vol. 61, No. 1 (January/February 2005), p. 45.

1988: A democratically elected government came to power, stifling the military's involvement in the country's nuclear program. See Rebecca K. C. Hersman and Robert Peters, "Nuclear U-Turns: Learning from the South Korean and Taiwanese Rollback," *Nonproliferation Review*, Vol. 13, No. 3 (November 2006), p.543.

1991: AVLIS enrichment experiments began (un-safeguarded/undeclared until 2004). See Jungmin Kang, Peter Hays, Li Bin, Tatsujiro Suzuki, and Richard Tanter, "South Korea's Nuclear Surprise," *Bulletin of the Atomic Scientists*, Vol. 61, No. 1 (January/February 2005), p. 45.

1994: The uranium conversion experiments ended. See Jungmin Kang, Peter Hays, Li Bin, Tatsujiro Suzuki, and Richard Tanter, "South Korea's Nuclear Surprise," *Bulletin of the Atomic Scientists*, Vol. 61, No. 1 (January/February 2005), p. 45.

2000: The AVLIS uranium enrichment experiments ended. See Jungmin Kang, Peter Hays, Li Bin, Tatsujiro Suzuki, and Richard Tanter, "South Korea's Nuclear Surprise," *Bulletin of the Atomic Scientists*, Vol. 61, No. 1 (January/February 2005), p. 45.

2004: The Additional Protocol was ratified. Past enrichment and separation experiments were declared. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/10/2007>).

Status in 2007: South Korea maintains 20 nuclear power units with 8 more planned or under construction. The Korean Atomic Research Institute (KAERI) has developed both pressurized water reactor (PWR) and CANDU fuel technology. South Korea is has ratified the CTBT and the Additional Protocol. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/ROK.pdf (accessed <8/10/2007>).

Taiwan

Taiwan's first nuclear research reactor went critical in 1956, placing Taiwan in the Nil Weapons Potential category. In 1967 the Taiwanese Defense Ministry and senior advisors proposed an effort to develop a secret nuclear arsenal, and the Hsin Chu Program was initiated. Under the military's authority, this program involved a commitment to procure a heavy-water reactor, a heavy-water production plant, and a plutonium separation plant. In 1968 Taiwan ratified the NPT. By 1972 a fuel fabrication plant was operational, and in 1973 a 40 MWt heavy-water research reactor went critical, moving Taiwan into the Modest Weapons Potential category. The move into the category for High Weapons Potential came in 1975, when the Plutonium Fuel Chemistry Laboratory for reprocessing plutonium became operational. In 1977 the US insisted that the heavy-water reactor be shut down and its core fuel elements be examined by Los Alamos Laboratory scientists in an effort to stop the potential removal of spent fuel. By 1978, however, Taiwan possessed 30 kg of separated plutonium. Thus, it was not until 1985, when the US and Taiwan reached an agreement to return to the US all of the spent fuel from the research reactor, that Taiwan moved down to the Modest Weapons Potential category. In 1987 the Institute for Nuclear Energy Research (headed by the military) began building a facility with multiple hot cells. It also resumed plutonium reprocessing efforts. This moved Taiwan back up to the High Weapons Potential category. In 1988, however, under US pressure, the hot cell facility shut down and an agreement was reached to return the remaining heavy water to the US. This moved Taiwan back down to the Modest Weapons Potential category. As of 2007 Taiwan has implemented the Additional Protocol safeguards and maintains 6 nuclear power units.

Key timeline data:

1956: Taiwan's first nuclear research reactor went critical. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/10/2007>).

1967: The Defense Ministry and senior advisors proposed an effort to develop a secret Taiwanese nuclear arsenal, the Hsin Chu Program. Placed under military control, this program was tasked with procuring a heavy-water reactor, a heavy-water production plant, and a plutonium separation plant and $140 million was authorized for this effort. See Rebecca K. C. Hersman and Robert Peters, "Nuclear U-Turns: Learning from the South Korean and Taiwanese Rollback," *Nonproliferation Review*, Vol. 13, No. 3 (November 2006), p. 543.

1968: Taiwan ratified the NPT and began negotiating a safeguards agreement with the IAEA. See IAEA.org, "Country Profile: South Korea," http://www.iaea.org/DataCenter/index.html (accessed <8/10/2007>).

1970s: The nuclear program was placed under civilian authority—the Atomic Energy Council, or AEC—though a senior military officer served on the board of the AEC. See David Albright and Corey Gay, "Taiwan: Nuclear Nightmare Averted," *Bulletin of Atomic Scientists*, Vol. 54, No. 1 (January/February 1998), p. 56.

1972: A fuel fabrication plant became operational. See David Albright and Corey Gay, "Taiwan: Nuclear Nightmare Averted," *Bulletin of Atomic Scientists*, Vol. 54, No. 1 (January/February 1998), p. 57.

1972: Taiwan, the US, and the IAEA negotiated a trilateral agreement on safeguards providing limited inspections. See Rebecca K.C. Hersman and Robert Peters, "Nuclear U-Turns: Learning from the South Korean and Taiwanese Rollback," *Nonproliferation Review*, Vol. 13, No. 3 (November 2006), p. 544.

1973: Taiwan's heavy-water research reactor went critical (40 MWt). See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/10/2007>).

1975: A plutonium fuel chemistry laboratory became operational. See David Albright and Corey Gay, "Taiwan: Nuclear Nightmare Averted," *Bulletin of Atomic Scientists*, Vol. 54, No. 1 (January/February 1998), p.56.

1976: Taiwan's leaders committed not to acquire reprocessing facilities. See David Albright and Corey Gay, "Taiwan: Nuclear Nightmare Averted," *Bulletin of Atomic Scientists*, Vol. 54, No. 1 (January/February 1998), p.58.

1977: The US insisted that the heavy-water reactor be shut down and its core fuel elements be examined by the Los Alamos Laboratory scientists in an effort to stop the potential removal of spent fuel. See Rebecca K.C. Hersman and Robert Peters, "Nuclear U-Turns: Learning from the South Korean and Taiwanese Rollback," *Nonproliferation Review*, Vol. 13, No. 3 (November 2006), p.544.

1978: Taiwan possessed 30 kg of separated plutonium. The US insisted that all US-supplied plutonium be returned. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), pp. 81, 97, 100 and David Albright and Corey Gay, "Taiwan: Nuclear Nightmare Averted," *Bulletin of Atomic Scientists*, Vol. 54, No. 1 (January/February 1998), p. 55.

1985: Agreement was reached to return to the US all of the spent fuel from the research reactor. See David Albright and Corey Gay, "Taiwan: Nuclear Nightmare Averted," *Bulletin of Atomic Scientists*, Vol. 54, No. 1 (January/February 1998), p. 59.

1987: The Institute for Nuclear Energy Research (headed by the military) began building a multiple hot cell facility. See David Albright and Corey Gay, "Taiwan: Nuclear Nightmare Averted," *Bulletin of Atomic Scientists*, Vol. 54, No. 1 (January/February 1998), p.59.

1988: Under US pressure, Taian shut down the hot cell facility and reached an agreement to return remaining heavy water to the US and to ban any weapons-related nuclear research. David Albright and Corey Gay, "Taiwan: Nuclear Nightmare Averted," *Bulletin of Atomic Scientists*, Vol. 54, No. 1 (January/February 1998), p.59.

Status in 2007: Taiwan maintains 6 nuclear power units and has implemented the Additional Protocol safeguards. See NTI.org, "Taiwan Profile," http://www.nti.org/e_research/profiles/Taiwan/index.html (accessed <8/10/2007>).

Thailand

Thailand acceded to the NPT in 1972. Its first research reactor went critical in 1997. As of 2007 all of Thailand's nuclear facilities are under IAEA safeguards, though it has signed but not ratified the Additional Protocol. This history places Thailand in the category of Nil Weapons Potential because, since the inception of its nuclear program, its capabilities have been limited to nuclear research.

Key timeline data:

1972: Thailand acceded to the NPT.

1977: First research reactor went critical.

1999: Construction began on a second research reactor.

Status in 2007: Taiwan has no nuclear power plants. Its research facilities operate under IAEA safeguards though it has signed but not ratified the Additional Protocol. See Federation of Atomic Scientists, "Weapons on Mass Destruction: Treaty on the Non-Proliferation of Nuclear Weapons," http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/8/2007>), and IAEA Research Reactor Data Base http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/8/2007>).

Vietnam

Vietnam's first research reactor went critical in 1963 (subject to IAEA safeguards). In 1975 Vietnam ratified the NPT. As of 2007 Vietnam has received IAEA board approval, but has neither signed nor ratified the Additional Protocol. Vietnam has one research reactor and no nuclear power plants. But it also has plans to bring a nuclear power plant on line by 2017. This history places Vietnam in the category of Nil Weapons Potential because, since the inception of its nuclear program, its capabilities have been limited to nuclear research.

Key timeline data:

1963: First research reactor went critical (subject to IAEA safeguards).

1975: NPT ratified.

Status in 2007: As summarized above. See Federation of Atomic Scientists, "Weapons on Mass Destruction: Treaty on the Non-Proliferation of Nuclear Weapons," http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/8/2007>), IAEA Research Reactor Data Base http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/8/2007>), and http://www.reachingcriticalwill.org/about/pubs/Inventory07/VietNam.pdf (accessed <8/8/2007>).

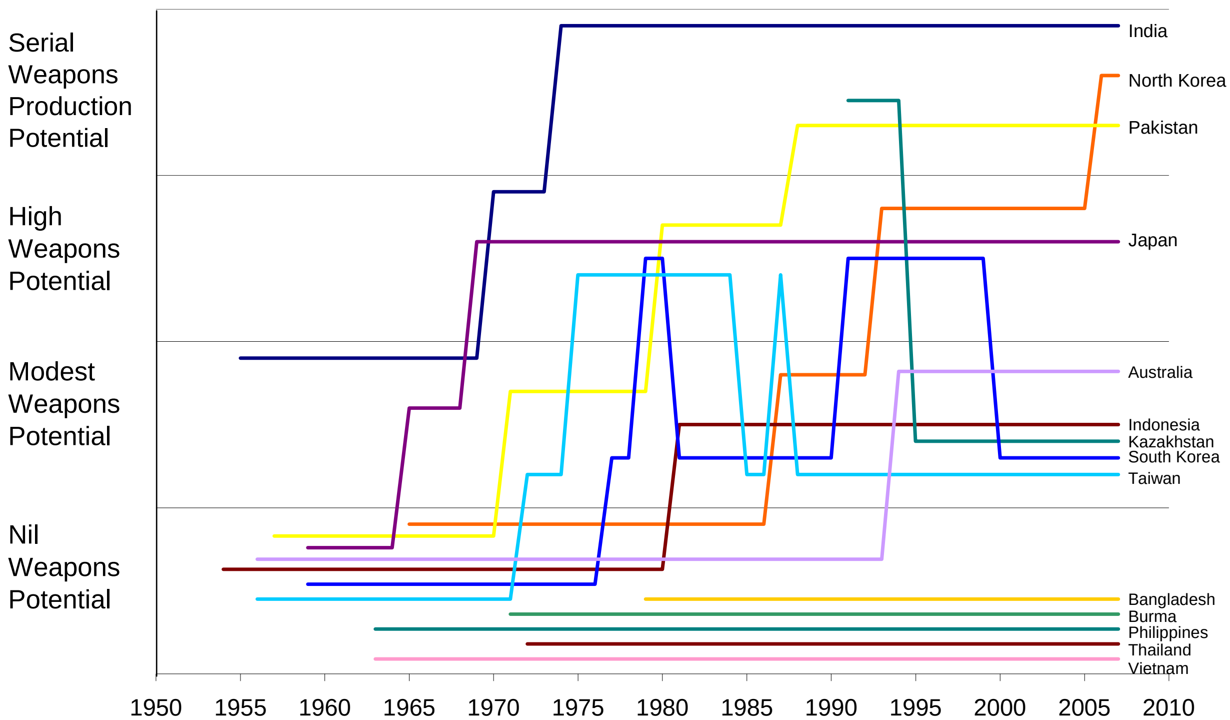

Figure 4. Asia's Nuclear Proliferation History

E. EUROPE

This region's nuclear history encompasses the experiences of the following countries:

- Armenia
- Belarus
- Belgium
- Bulgaria
- Canada (though not in Europe, a NATO ally)
- Czech Republic
- Finland
- Germany
- Hungary
- Italy
- Lithuania
- Netherlands
- Norway
- Romania
- Serbia
- Slovakia
- Slovenia
- Spain
- Sweden
- Switzerland
- Ukraine

A graphic depiction of this information appears at figure 5 at the end of this section.

Armenia

Armenia's first nuclear power unit became operational in 1976, placing it in the Modest Weapons Potential category. In 1993 Armenia acceded to the NPT and in 2004 ratified the Additional Protocol. Presently, Armenia maintains one nuclear power unit. Additionally, Armenia is conducting a feasibility study for building a new reactor at the Armenian nuclear power plant. The study is scheduled to be completed in 1–2 years.

Key timeline data:

1976: First nuclear power unit became operational. See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/23/2007>).

1993: Armenia acceded to the NPT. See Federation of Atomic Scientists, "Weapons on Mass Destruction: Treaty on the Non-Proliferation of Nuclear Weapons," http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/23/2007>).

1994: Comprehensive safeguards agreement with the IAEA was ratified. See IAEA.org, "Country Profile: Armenia," http://www.iaea.org/DataCenter/index.html (accessed <8/23/2007>).

2004: Additional Protocol was ratified. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/23/2007>).

Status in 2007: Armenia maintains 1 nuclear power unit but intends to begin construction in 2008 on a South African-designed Pebble Bed Reactor in 2009. See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/23/2007>).

Belarus

With the collapse of the Soviet Union in 1991, Belarus inherited approximately 800 nuclear warheads. This placed Belarus in the Potential for Serial Weapons Production category. By 1993 the tactical nuclear weapons had been completely withdrawn from Belarus and the Belarusian Supreme Council voted to accede to the NPT as a non-nuclear state. In 1996 the last of the nuclear warheads were removed, moving Belarus into the Nil Weapons Potential category. As of 2007 Belarus has no nuclear industry, and has signed but not ratified the Additional Protocol.

Key timeline data:

1991: With the collapse of the Soviet Union, Belarus inherited approximately 800 nuclear warheads, both tactical and strategic. See Joseph Cirincione, Jon B. Wolfsthal and Miriam Rajkumar, *Deadly Arsenals Nuclear, Biological, and Chemical Threats* 2nd edition (Washington D.C.: Carnegie Endowment for International Peace, 2005), p. 367.

1992: The Minister of Defense stated that Belarus intended to be nuclear free, and Belarus signed the Lisbon Protocol. See Mark D. Skootsky, "An Annotated Chronology of Post-Soviet Nuclear Disarmament 1991–1994," *Nonproliferation Review*, Vol. 2, No. 3 (Summer/Spring 1995), pp. 70–72.

1993: The withdrawal of tactical nuclear weapons was completed. The Belarusian Supreme Council ratified START I and voted to accede to the NPT as a non-weapon state. See Mark D. Skootsky, "An Annotated Chronology of Post-Soviet Nuclear Disarmament 1991-1994," *Nonproliferation Review*, Vol. 2, No. 3 (Summer/Spring 1995), p. 73.

1994: A safeguards agreement with the IAEA was approved. See Mark D. Skootsky, "An Annotated Chronology of Post-Soviet Nuclear Disarmament 1991-1994," *Nonproliferation Review*, Vol. 2, No. 3 (Summer/Spring 1995), p. 94.

1996: Withdrawal of nuclear warheads to Russia was concluded. See Joseph Cirincione, Jon B. Wolfsthal, and Miriam Rajkumar, *Deadly Arsenals Nuclear, Biological, and Chemical Threats* 2nd edition (Washington D.C.: Carnegie Endowment for International Peace, 2005), p. 367.

2005: Additional Protocol was signed. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/14/2007>).

Status in 2007: Belarus has no nuclear industry. It has signed but not ratified the Additional Protocol. See Nuclear Weapons Archive, "Belarus," http://nuclearweaponarchive.org/Nwfaq/Nfaq7-4.html#Belarus (accessed <8/14/2007>).

Belgium

Belgium's first research reactor went critical in 1956, placing Belgium in the Nil Weapons Potential category. By 1961 Belgium's first commercial fuel fabrication facility was operational. Its first nuclear power unit went critical a year later. These developments moved Belgium into the Modest Weapons Potential category. In 1966 Belgium's PUREX reprocessing demonstration facility was complete, moving Belgium into the High Weapons Potential category. In 1975, however, Belgium ratified the NPT and shut down its PUREX reprocessing facility, moving Belgium back down into the Modest Weapons Potential category. In 2004 Belgium ratified the Additional Protocol. At present it maintains 7 nuclear power units and 4 research reactors under full IAEA safeguards.

Key timeline data:

1956: Belgium's first research reactor went critical. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/23/2007>).

1961: A commercial fuel fabrication facility became operational. See *Country Nuclear Fuel Cycle Profiles*, 2nd edition, International Atomic Energy Agency, Technical Reports Series No 425 (Vienna: IAEA, 2005), p. 18.

1962: Belgium's first nuclear power unit went critical. See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/23/2007>).

1966: The PUREX reprocessing demonstration facility was completed. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 93.

1975: The NPT was ratified. See Federation of Atomic Scientists, “Weapons of Mass Destruction: Treaty on the Non-Proliferation of Nuclear Weapons,” http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/23/2007>).

1975: The PUREX reprocessing facility was shut down. See M. D. Zentner, G. L. Coles, and R. J. Talbert, “Nuclear Proliferation Technology Trends Analysis,” Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 93.

1977: A comprehensive safeguards agreement with the IAEA was ratified. See IAEA.org, “Country Profile: Belgium,” http://www.iaea.org/DataCenter/index.html (accessed <8/23/2007>).

2004: The Additional Protocol was ratified. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/23/2007>).

Status in 2007: Belgium maintains 7 nuclear power units and 4 research reactors under full IAEA safeguards. It has also ratified the CTBT. It also hosts US nuclear weapons under the NATO nuclear sharing policy. See: :http://www.reachingcriticalwill.org/about/pubs/Inventory07/Belgium.pdf (accessed <8/23/2007>).

Bulgaria

Bulgaria’s first nuclear research reactor became operational in 1961, placing Bulgaria in the Nil Weapons Potential category. Bulgaria ratified the NPT in 1969. It moved into the Modest Weapons Potential category when its first nuclear power unit became operational in 1974. In 2000 Bulgaria ratified the Additional Protocol. As of 2007 it maintains 2 nuclear power units and has two more under construction.

Key timeline data:

1961: The first nuclear research reactor became operational. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/23/2007>).

1969: Bulgaria ratified the NPT. See Federation of Atomic Scientists, “Weapons on Mass Destruction: Treaty on the Non-Proliferation of Nuclear Weapons,” http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/23/2007>).

1972: A comprehensive safeguards agreement with the IAEA was ratified. See IAEA.org, “Country Profile: Bulgaria,” http://www.iaea.org/DataCenter/index.html (accessed <8/23/2007>).

1974: The first nuclear power unit became operational. See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/23/2007>).

2000: The Additional Protocol was ratified. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/23/2007>).

Status in 2007: Bulgaria maintains 2 nuclear power units under full IAEA safeguards and has two more under construction. It has also ratified the Comprehensive Nuclear Test-Ban Treaty. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Bulgaria.pdf (accessed <8/23/2007>).

Canada

Canada participated in the Manhattan Project in World War II, providing expertise on uranium mining, milling, refining, and conversion and on heavy water production. In 1944 Canadian engineers began developing a pressurized heavy water nuclear reactor, the basis for the CANDU heavy-water power reactor system, which was produced in small scale prototype by 1955. These developments placed Canada in the Modest Weapons Potential category. In 1969 Canada ratified NPT. It ratified the Additional Protocol in 2000. As of 2007, Canada maintains 18 nuclear power reactors and 8 research reactors under full scope IAEA safeguards.

Key timeline data:

1940s: Canada participated in the Manhattan Project, providing expertise on uranium mining, milling, refining and conversion and on heavy water production . See T.V. Paul, *Power Versus Prudence: Why States Forgo Nuclear Weapons* (Montreal: McGill-Queen's University Press, 2000), p. 63.

1944: Canadian engineers began to develop a pressurized heavy water nuclear reactor, which became the basis for the CANDU heavy-water power reactor system. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Canada.pdf (accessed <8/13/2007>).

1955: The first small-scale prototype heavy-water CANDU reactor was completed. See IAEA.org, "Country Profile: Canada," http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

1958: The Difenbaker government began to procure delivery systems capable of employing US tactical and strategic weapons. See Don Munton, "Going Fission: Tales and Truths about Canada's Nuclear Weapons Program," *International Journal* (Summer 1996), p. 507.

1963: Canadian units were equipped with US nuclear warheads. See PBS.org, "Tracking Nuclear Proliferation: Canada," http://www.pbs.org/newshour/indepth_coverage/military/proliferation/countries/canada.html (accessed <8/13/2007>).

1969: Canada ratified the NPT. See IAEA.org, "Country Profile: Canada," http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

1970: Removal of US nuclear weapons from Canadian bases began. See T.V. Paul, *Power Versus Prudence: Why States Forgo Nuclear Weapons* (Montreal: McGill-Queen's University Press, 2000), p. 67.

1972: A comprehensive safeguards agreement with the IAEA was ratified. See IAEA.org, "Country Profile: Canada," http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

1979: The world's largest heavy-water production plant became operational. See World Nuclear Association, "Canada's Uranium Production and Nuclear Power," http://www.world-nuclear.org/info/inf49.html (accessed <8/13/2007>).

1983: The world's largest uranium refinery became operational. See World Nuclear Association, "Canada's Uranium Production and Nuclear Power," http://www.world-nuclear.org/info/inf49.html (accessed <8/13/2007>).

1984: The last of the US nuclear warheads were removed from Canadian territory. See PBS.org, "Tracking Nuclear Proliferation: Canada," http://www.pbs.org/newshour/indepth_coverage/military/proliferation/countries/canada.html (accessed <8/13/2007>).

2000: Canada ratified the Additional Protocol. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

Status in 2007: Canada maintains 18 nuclear power reactors and 8 research reactors and has mining, milling, conversion and fuel fabrication facilities along with heavy-water production facilities, all operating under full scope IAEA safeguards. It has also ratified the CTBT. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Canada.pdf (accessed <8/13/2007>).

Czech Republic

Czechoslovakia's first nuclear research reactor became operational in 1957, moving the country into the Nil Weapons Potential category. In 1973 Czechoslovakia ratified the NPT. In 1985 its first nuclear power unit became operational, moving it into the Modest Weapons Potential category. In 2000 the Czech Republic, by then an independent entity, ratified the Additional Protocol. As of 2007 it maintains six nuclear power units and three research reactors under full-scope safeguards.

Key timeline data:

1957: First nuclear research reactor became operational (in the then Czechoslovakia). See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/23/2007>).

1973: NPT was ratified. See Federation of Atomic Scientists, "Weapons on Mass Destruction: Treaty on the Non-Proliferation of Nuclear Weapons," http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/23/2007>).

1985: First nuclear power unit became operational. See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/23/2007>).

1997: A comprehensive safeguards agreement with the IAEA was ratified by the independent Czech Republic. See IAEA.org, "Country Profile: Czech Republic," http://www.iaea.org/DataCenter/index.html (accessed <8/23/2007>).

2000: The Additional Protocol was ratified. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/23/2007>).

Status in 2007: The Czech Republic maintains 6 nuclear power unit and 3 research reactors; under full scope IAEA safeguards. It has also ratified the CTBT. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Czech.pdf (accessed <8/23/2007>).

Finland

Finland's first uranium production mine became operational in 1958. Its first research reactor became operational in 1962, bringing Finland into the Nil Weapons Potential category. In 1970 Finland ratified the NPT. In 1977 Finland's first nuclear power reactor became operational, moving Finland into the Modest Weapons Potential category. In 2004 Finland ratified the Additional Protocol. As of 2007 it maintains 4 nuclear power reactors and 1 research reactor.

Key timeline data:

1958: First uranium production mine became operational. See *Country Nuclear Fuel Cycle Profiles*, 2nd edition, International Atomic Energy Agency, Technical Reports Series No 425 (Vienna: IAEA, 2005), p. 38.

1962: First research reactor became operational. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/13/2007>).

1970: Finland ratified the NPT. See IAEA.org, "Country Profile: Finland," http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

1972: A comprehensive safeguards agreement with the IAEA was ratified. See IAEA.org, "Country Profile: Finland," http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

1977: The first nuclear power reactor became operational. See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/13/2007>).

1982: Four nuclear power units were operational. See IAEA.org, "Country Profile: Finland," http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

2001: The Finnish parliament ratified the decision to build a fifth nuclear power unit. See *Country Nuclear Fuel Cycle Profiles*, 2nd edition, International Atomic Energy Agency, Technical Reports Series No 425 (Vienna: IAEA, 2005), p. 38.

2004: The Additional Protocol was ratified. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

Status in 2007: Finland maintains four nuclear power reactors and one research reactor, and a fifth reactor is under construction that should be operational in 2009. It has also ratified the CTBT. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Finland.pdf (accessed <8/13/2007>).

Germany

(West) Germany made a unilateral nuclear non-acquisition declaration in the Paris Accords of 1954, and this commitment was also expressed in its basic law or constitution. A possible cooperative effort with France and Italy to acquire nuclear arms was proposed by Defense Minister Strauss in 1957, but a year later French President Charles de Gaulle put a stop to discussion of that possibility. In 1960 Germany initiated an isotope separation program. Germany moved into the Modest Weapons Potential category in 1961 when its first nuclear power unit became operational. In 1964 Germany formed the first commercial company intended to develop a reliable and economic centrifuge for uranium enrichment on an industrial scale. Germany ratified the NPT in 1975. In 1976 Germany provided the first demonstrated operational capability of its isotope separation facility. Because of the substantial inefficiencies associated with this enrichment technology, however, it was not until 1985 when the URENCO enrichment plant became operational at Gronau that Germany moved into the High Weapons Potential category. In 2004 Germany ratified the Additional Protocol. As of 2007 Germany maintains 17 power reactors and 12 research reactors.

Key timeline data:

1954: (West) Germany offered a unilateral declaration of nuclear non-acquisition with the Paris Accords. See T.V. Paul, *Power Versus Prudence: Why States Forgo Nuclear Weapons* (Montreal: McGill-Queen's University Press, 2000), p. 39.

1957: Defense Minister Strauss undertook a diplomatic initiative to acquire nuclear arms in a joint project with France and Italy. See T.V. Paul, *Power Versus Prudence: Why States Forgo Nuclear Weapons* (Montreal: McGill-Queen's University Press, 2000), p. 39.

1958: French President Charles de Gaulle called a halt to discussion of a trilateral development effort. See T.V. Paul, *Power Versus Prudence: Why States Forgo Nuclear Weapons* (Montreal: McGill-Queen's University Press, 2000), p. 40.

1960: An isotope separation program was initiated. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 13.

1960: Construction began on East Germany's first nuclear power unit (Rheinesberg). See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/13/2007>).

1961: The first nuclear power unit became operational. See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/13/2007>).

1964: The first commercial company intended to develop a reliable and economic centrifuge for uranium enrichment on an industrial scale was formed. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 21.

1966: East Germany's first nuclear power unit became operational. See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/13/2007>).

1967: A laboratory-scale isotope separation pilot-plant was completed. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 55.

1970: Construction began on a second East Germany nuclear power plant, Greifswald (8 units planned). See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/13/2007>).

1971: West Germany's first reprocessing plant became operational. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 94.

1975: West Germany ratified the NPT. See IAEA.org, "Country Profile: Germany," http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

1976: Isotope separation facility demonstrated operational capability. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 55.

1977: A comprehensive safeguards agreement with the IAEA was ratified. See IAEA.org, "Country Profile: Germany," http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

1979: Four of the eight planned nuclear power units were operational at Greifswald (East Germany). See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/13/2007>).

1985: The URENCO enrichment plant at Gronau became operational. See Urenco Deutschland, "Company History," http://www.urenco.com/fullArticle.aspx?m=1541 (accessed <8/13/2007>).

1990: German reunification.

1991: The reprocessing facility was shut down. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 94.

2000: New German government announced the intention to phase out the use of nuclear power. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Germany.pdf (accessed <8/13/2007>).

2004: The Additional Protocol was ratified. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

Status in 2007: Germany operates 17 power reactors and 12 research reactors and possesses a closed fuel cycle capability, all under full international safeguards.. It also hosts US nuclear weapons under the NATO nuclear sharing policy. See: http://www.reachingcriticalwill.org/about/pubs/Inventory07/Germany.pdf (accessed <8/13/2007>).

Hungary

Hungary's first nuclear research reactor became operational in 1959, placing Hungary in the Nil Weapons Potential category. It ratified the NPT in 1969. Hungary moved into the Modest Weapons Potential category when its first nuclear power unit became operational in 1982. In 2000 Hungary ratified the Additional Protocol. At present Hungary maintains four nuclear power reactors and three research reactors.

Key timeline data:

1959: First nuclear research reactor became operational. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/23/2007>).

1969: Hungary ratified the NPT. See Federation of Atomic Scientists, "Weapons on Mass Destruction: Treaty on the Non-Proliferation of Nuclear Weapons," http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/23/2007>).

1972: A comprehensive safeguards agreement with the IAEA was ratified. See IAEA.org, "Country Profile: Hungary," http://www.iaea.org/DataCenter/index.html (accessed <8/23/2007>).

1982: The first nuclear power unit became operational. See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/23/2007>).

2000: The Additional Protocol was ratified. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/23/2007>).

Status in 2007: Hungary maintains four nuclear power units and three research reactors and operates them under full-scope IAEA safeguards. It has also ratified the CTBT. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Hungary.pdf (accessed <8/23/2007>).

Italy

In 1957 Italy became involved in discussions with Germany and France about a possible joint weapons development program. The discussions ended in 1958. In 1959 Italy's first research reactor became operational, placing it in the Nil Weapons Potential category. It moved into the Modest Weapons Potential category in 1963, when its first nuclear power reactor became operational. In 1966 a small reprocessing facility was built in Taranto. In 1975 Italy ratified the NPT. At the same time, designs for a large reprocessing plant were developed, but the facility was not built. In 1990 all four of Italy's nuclear power reactors were shut down. In 2004 Italy ratified the Additional Protocol. As of 2007 Italy operates five nuclear research reactors and because of this latent scientific capability remains in the Modest Weapons Potential category.

Key timeline data:

1957: The possibility of joint development activities with Germany and France was explored. See T.V. Paul, *Power Versus Prudence: Why States Forgo Nuclear Weapons* (Montreal: McGill-Queen's University Press, 2000), p. 39.

1958: French President de Gaulle ended the prospective nuclear force cooperation project See T.V. Paul, *Power Versus Prudence: Why States Forgo Nuclear Weapons* (Montreal: McGill-Queen's University Press, 2000), p. 39.

1959: Italy's first research reactor became operational. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/13/2007>).

1965: Three commercial nuclear power plants became operational. See IAEA.org, "Country Profile: Italy," http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

1966: A small reprocessing facility was built in Taranto. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 95.

1970: Pilot-scale plutonium reprocessing facility, Eurex SFRE, operational (0.3 t HM/year). See IAEA Nuclear Fuel Cycle Information System, http://www-nfcis.iaea.org/NFCIS/NFCISMain.asp?RPage=1&RightP=List (accessed <3/2/2008>).

1975: Italy ratified the NPT. See IAEA.org, "Country Profile: Italy," http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

1975: Designs for a large reprocessing plant were developed, but the facility was not built. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 95.

1975: Pilot-scale plutonium reprocessing facility, ITREC, operational (5 t HM/year). See IAEA Nuclear Fuel Cycle Information System, http://www-nfcis.iaea.org/NFCIS/NFCISMain.asp?RPage=1&RightP=List (accessed <3/2/2008>).

1977: A comprehensive safeguards agreement with the IAEA was ratified. See IAEA.org, "Country Profile: Italy," http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

1980: Pilot-scale plutonium reprocessing facility, Eurex SFRE (Oxide), operational (10 t HM/year). See IAEA Nuclear Fuel Cycle Information System, http://www-nfcis.iaea.org/NFCIS/NFCISMain.asp?RPage=1&RightP=List (accessed <3/2/2008>).

1988: Pilot-scale plutonium reprocessing facility, Eurex SFRE (Pu Nitrate Line), operational (0.1 t HM/year). See IAEA Nuclear Fuel Cycle Information System, http://www-nfcis.iaea.org/NFCIS/NFCISMain.asp?RPage=1&RightP=List (accessed <3/2/2008>).

1988: Pilot-scale plutonium reprocessing facility, ITREC, decommissioned (5 t HM/year). See IAEA Nuclear Fuel Cycle Information System, http://www-nfcis.iaea.org/NFCIS/NFCISMain.asp?RPage=1&RightP=List (accessed <3/2/2008>).

1990: Both pilot-scale plutonium reprocessing facilities, Eurex SFRE and Eurex SFRE (Oxide), decommissioned. See IAEA Nuclear Fuel Cycle Information System, http://www-nfcis.iaea.org/NFCIS/NFCISMain.asp?RPage=1&RightP=List (accessed <3/2/2008>).

1990: All four nuclear power reactors were shut down. See IAEA.org, "Country Profile: Italy," http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

2004: The Additional Protocol was ratified. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

Status in 2007: Italy has no nuclear power facilities but operates five nuclear research reactors under full-scope IAEA safeguards. It has signed the CTBT. It also hosts US nuclear weapons under the NATO nuclear-sharing policy. See: http://www.reachingcriticalwill.org/about/pubs/Inventory07/Italy.pdf (accessed <8/13/2007>).

Lithuania

Lithuania's first nuclear power reactor became operational in 1984, and in its second power reactor became operational in 1987, placing Lithuania in the Modest Weapons Potential category. In 1991 Lithuania acceded to the NPT, and in 2000 it ratified the Additional Protocol. In 2004 Lithuania's first nuclear power reactor was permanently shut down. As of 2007 Lithuania maintains a single nuclear power reactor.

Key timeline data:

1984: First nuclear power unit became operational. See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/23/2007>).

1987: Second nuclear power unit became operational. See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/23/2007>).

1991: Lithuania acceded to the NPT. See Federation of Atomic Scientists, "Weapons on Mass Destruction: Treaty on the Non-Proliferation of Nuclear Weapons," http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/23/2007>).

1992: A comprehensive safeguards agreement with the IAEA was ratified. See IAEA.org, "Country Profile: Lithuania," http://www.iaea.org/DataCenter/index.html (accessed <8/23/2007>).

2000: The Additional Protocol was ratified. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/23/2007>).

2004: First nuclear power unit was permanently shut down. See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/23/2007>).

Status in 2007: Lithuania maintains a single nuclear power unit under full-scope IAEA safeguards. See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/23/2007>).

Netherlands

The Netherlands' first research reactor went critical in 1960. It moved into the Modest Weapons Potential category in 1969 when its first nuclear power reactor became operational. In 1970 URENCO was established. Three test facilities to enrich uranium were built and in 1973 the first full-scale uranium enrichment facility became operational, moving The Netherlands into the High Weapons Potential category. In 1975 The Netherlands ratified the NPT. By 1981 the Almelo uranium enrichment facility was operational. In 2004 The Netherlands ratified the Additional Protocol. As of 2007 the Netherlands operates a single power reactor and three research reactors.

Key timeline data:

1960: First research reactor went critical. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/13/2007>).

1968: First nuclear power reactor became operational. See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/13/2007>).

1970: URENCO was established and three test facilities to enrich uranium were begun. See: M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 21.

1973: The first full-scale uranium enrichment facility became operational. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 21.

1975: The NPT was ratified. See IAEA.org, "Country Profile: The Netherlands," http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

1981: A uranium enrichment facility became operational at Almelo. See World Nuclear Association, "Nuclear Power in the Netherlands," http://www.world-nuclear.org/info/inf107.html (accessed <8/13/2007>).

1985: Plans to expand the number of nuclear power units in the country were suspended. See IAEA.org, "Country Profile: The Netherlands," http://www.iaea.org/DataCenter/index.html accessed <8/13/2007>).

1997: A comprehensive safeguards agreement with the IAEA was ratified. See IAEA.org, "Country Profile: The Netherlands," http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

2004: The Additional Protocol was ratified. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

Status in 2007: The Netherlands operates a single power reactor and three research reactors, all under full-scope IAEA safeguards. It also possesses a uranium enrichment capability. It has ratified the CTBT. It hosts US nuclear weapons under the NATO nuclear-sharing policy. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Netherlands.pdf (accessed <8/13/2007>).

Norway

The Norwegian Defense Research Establishment (NDRE) was created in 1946 and directed to do nuclear research for defensive purposes. In 1951 an experimental heavy water research reactor, Kjeller, went critical. Because this predated the creation of the IAEA, this activity was un-safeguarded. It also moved Norway into the Modest Weapons Potential category (on the basis of the assessment that heavy water research reactors are a route to plutonium production). In 1954 Norwegian researchers developed a technique for plutonium separation and began plutonium extraction experiments. This moved Norway up another category, into the High Weapons Potential category. In 1959 another heavy-water research reactor (25 MWt) went critical. The pilot-scale PUREX plutonium reprocessing facility, Pilot Uranium Reprocessing Plant, was decommissioned in 1968. In 1969 Norway ratified the NPT. However, separation of plutonium continued on a small-scale until the early 1970s; scientists had extracted 200 grams of plutonium by the time such experiments ended. Cessation of this work, in addition to the fact that a comprehensive safeguards agreement with the IAEA was ratified in 1972, moved Norway down into the Nil Weapons Potential category. In 2000 Norway ratified the Additional Protocol. As of 2007 it operates two research reactors and no power reactors.

Key timeline data:

1946: The NDRE was created and directed to do nuclear research for defensive purposes. See Astrid Forland, "Norway's Nuclear Odyssey: From Optimistic Proponent to Nonproliferator," *Nonproliferation Review*, Vol. 4, No. 2 (Winter 1997), p. 2.

1951: An experimental heavy-water research reactor, Kjeller (2MWt), went critical (un-safeguarded). See Astrid Forland, "Norway's Nuclear Odyssey: From Optimistic Proponent to Nonproliferator," *Nonproliferation Review*, Vol. 4, No. 2 (Winter 1997), p. 6.

1954: Researchers developed a technique for plutonium separation, and plutonium extraction experiments began. See Astrid Forland, "Norway's Nuclear Odyssey: From Optimistic Proponent to Nonproliferator," *Nonproliferation Review*, Vol. 4, No. 2 (Winter 1997), p. 9.

1959: A second heavy-water research reactor went critical (25 MWt). See Source: IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/15/2007>).

1959: Norway sold 20 tons of heavy water to Israel. See Astrid Forland, "Norway's Nuclear Odyssey: From Optimistic Proponent to Nonproliferator," *Nonproliferation Review*, Vol. 4, No. 2 (Winter 1997), p. 10.

1960s: The head of NDRE helped the IAEA to develop safeguards criteria and processes. See Astrid Forland, "Norway's Nuclear Odyssey: From Optimistic Proponent to Nonproliferator," *Nonproliferation Review*, Vol. 4, No. 2 (Winter 1997), p. 13.

1961: Pilot-scale PUREX plutonium reprocessing facility, Pilot Uranium Reprocessing Plant, operational (0 t HM/year). See IAEA Nuclear Fuel Cycle Information System, http://www-nfcis.iaea.org/NFCIS/NFCISMain.asp?RPage=1&RightP=List (accessed <3/2/2008>).

1962: Norwegian government assuranced the international community that it had no intention to acquire nuclear weapons. See Astrid Forland, "Norway's Nuclear Odyssey: From Optimistic Proponent to Nonproliferator," *Nonproliferation Review*, Vol. 4, No. 2 (Winter 1997), p. 13.

1968: Pilot-scale PUREX plutonium reprocessing facility, Pilot Uranium Reprocessing Plant, decommissioned. See IAEA Nuclear Fuel Cycle Information System, http://www-nfcis.iaea.org/NFCIS/NFCISMain.asp?RPage=1&RightP=List (accessed <3/2/2008>).

1969: The NPT was ratified. See IAEA.org, "Country Profile: Norway," http://www.iaea.org/DataCenter/index.html (accessed <8/15/2007>).

1970s: Plutonium separation continued on a small scale until the early 1970s, resulting in an accumulation of approximately 200 grams. See Astrid Forland, "Norway's Nuclear Odyssey: From Optimistic Proponent to Nonproliferator," *Nonproliferation Review*, Vol. 4, No. 2 (Winter 1997), p. 9.

1972: A comprehensive safeguards agreement with the IAEA was ratified. See IAEA.org, "Country Profile: Norway," http://www.iaea.org/DataCenter/index.html (accessed <8/15/2007>).

2000: The Additional Protocol was ratified. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/15/2007>).

Status in 2007: Norway operates two research reactors (under full safeguards) and no power reactor. It has ratified the CTBT. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Norway.pdf (accessed <8/15/2007>).

Romania

Romania's uranium mining activities began in 1952. Its first research reactor went critical in 1957. These developments placed Romania in the Nil Weapons Potential category. In 1965 a covert nuclear weapons program was begun by Romanian dictator Nicolae Ceausescu. In 1970 Romania ratified the NPT and a comprehensive safeguards agreement with the IAEA. In 1979 two more research reactors went critical at the Pitesti facility, moving Romania into the Modest Weapons Potential category. In 1982–83 construction began on two nuclear power reactors (CANDU). A fuel fabrication facility became operational in 1985. Also in 1985, 100 milligrams of plutonium was separated at the Pitesti Nuclear Research Institute in hot laboratories. Because these plutonium separation experiments were undeclared and un-safeguarded, they moved Romania into the High Weapons Potential category. Romania also developed a heavy water production capability, and in 1988 the ROMAG-PROD Heavy Water Plant became operational. In 1989 Ceausescu was overthrown and the nuclear weapons program was abandoned. However, it was not until 1992 that the Romanian government discovered the separated plutonium, reported its discovery to the IAEA, and agreed to full IAEA inspections and control of its facilities that Romania moved back down into the Modest Weapons Potential category. In 1996 Romania's first nuclear power reactor became operational (CANDU). In 2000 Romania ratified the Additional Protocol. As of 2007 Romania maintains one nuclear power reactor with one under construction and three more planned.

Key timeline data:

1952: Uranium mining began. See *Country Nuclear Fuel Cycle Profiles*, 2nd edition, International Atomic Energy Agency, Technical Reports Series No 425 (Vienna: IAEA, 2005), p. 67.

1957: The first research reactor (14 MWt TRIGA) went critical. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/13/2007>).

1965: A covert nuclear weapons program was begun by Romanian dictator Nicolae Ceausescu. See PBS.org, "Tracking Nuclear Proliferation: Romania," http://www.pbs.org/newshour/indepth_coverage/military/proliferation/countries/romania.html (accessed <8/13/2007>).

1970: Romania ratified the NPT as well as a comprehensive safeguards agreement with the IAEA. See IAEA.org, "Country Profile: Romania," http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

1979: Two more research reactors went critical (Pitesti facility). See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/13/2007>).

1982-83: Construction began on two nuclear power reactors (CANDU). See IAEA.org, "Country Profile: Romania," http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

1985: A fuel fabrication facility became operational. See World Information Service on Energy, "Nuclear Power Programs in Future Member States: Romania," http://www10.antenna.nl/wise/index.html?http://www10.antenna.nl/wise/596-8/h4.php (accessed <8/13/2007>).

1985: 100 milligrams of plutonium was separated at the Pitesti Nuclear Research Institute in hot laboratories. See PBS.org, "Tracking Nuclear Proliferation: Romania," http://www.pbs.org/newshour/indepth_coverage/military/proliferation/countries/romania.html (accessed <8/13/2007>).

1988: ROMAG-PROD Heavy Water Plant operational. See IAEA-CN-123/04/P/08, "Young Generation in Romanian Nuclear System – Romanian Nuclear Organizations Implication in Nuclear Knowledge and Management at University "Polithenica" of Bucharest: Results and Expectations," http://www.iaea.org/km/cnkm/papers/ghizdeanu.pdf (accessed <8/13/2007>).

1989: Ceausescu was removed from power and the nuclear weapons program was abandoned. See PBS.org, "Tracking Nuclear Proliferation: Romania," http://www.pbs.org/newshour/indepth_coverage/military/proliferation/countries/romania.html (accessed <8/13/2007>).

1992: Commercial-scale fuel fabrication facility operational. See *Country Nuclear Fuel Cycle Profiles*, 2nd edition, International Atomic Energy Agency, Technical Reports Series No 425 (Vienna: IAEA, 2005), p. 20.

1992: Romania contacted the International Atomic Energy Agency to report the discovery of the 100 milligrams of plutonium that had been separated in December 1985 at the Pitesti Nuclear Research Institute. After Bucharest reported its discovery it agreed to suspend its nuclear activities and install IAEA monitoring devices at its facilities. See PBS.org, "Tracking Nuclear Proliferation: Romania," http://www.pbs.org/newshour/indepth_coverage/military/proliferation/countries/romania.html (accessed <8/13/2007>).

1996: First nuclear power reactor became operational (CANDU). See IAEA.org Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/13/2007>).

2000: The Additional Protocol was ratified. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

Status in 2007: Romania operates a single nuclear power reactor with an additional unit under construction and three more planned. It has uranium mining, conversion, and fabrication capabilities, as well as those for heavy water production. It has ratified the CTBT. See: http://www.reachingcriticalwill.org/about/pubs/Inventory07/Romania.pdf (accessed <8/13/2007>) and *Country Nuclear Fuel Cycle Profiles*, 2nd edition, International Atomic Energy Agency, Technical Reports Series No 425 (Vienna: IAEA, 2005), p. 67-8.

Serbia (Former Yugoslavia)

In the mid-1940s the government of Josip Broz Tito decided to develop the capability to produce nuclear weapons. Yugoslavia's first nuclear research reactor center, the Vinca Institute of Nuclear Sciences, was established in 1948. A decade later, the first nuclear research reactor went critical at Vinca (RB) – heavy-water moderated, 250 kW. The following year another research reactor went critical with a capacity of 6.5 MWt. These research capabilities placed Yugoslavia in the Nil Weapons Potential category. In the early 1960s, Tito deactivated the nuclear weapons program. But in 1962 Yugoslavia received blueprints for a reprocessing plant. By 1966 a laboratory-scale plutonium reprocessing facility was operational at Vinca. This development moved Yugoslavia into the Modest Weapons Potential category. In 1970 Yugoslavia ratified the NPT. In 1974 Tito called a top-secret meeting with the heads of the major nuclear research institutes and representatives from the military and intelligence services, and ordered them to use the country's nuclear power program as a camouflage for a parallel nuclear weapons program, deemed "Program A." In 1976 the former Soviet Union supplied 48.2 kg of 80 percent enriched uranium fuel, in metal form, for the RA reactor. With access to over 48 kg of fissile material, Yugoslavia moved into the High Weapons Potential category. In 1978, the reprocessing research ended and the equipment was removed from the Vinca laboratories and placed under IAEA safeguards. Cumulatively, these experiments may have resulted in the separation of between several grams and 1 kilogram of plutonium. In 1981 Yugoslavia's first nuclear power plant became operational, in what is now Slovenia. With regime change in Belgrade, "Program A" lost vital political support. In 1995, another Yugoslav vestige, Macedonia, acceded to the NPT. But Serbia resisted formally acceding to the NPT, arguing that is should be accepted as the sole successor to the Socialist Republic of Yugoslavia. In 2002 the 48 kg of HEU were removed from Vinca Institute to the Russian Institute of Atomic Reactors. The removal of this material moved Serbia into the Nil Weapons Potential category because Serbia's nuclear facilities consist of one research reactor. In 2004 Serbia was approved by the IAEA board for ratification of the Additional Protocol. As of 2007 Serbia has signed but not ratified the Additional Protocol.

Key timeline data:

1940s: Government of Josip Broz Tito decided to develop the capability to produce nuclear weapons. See William C. Potter, Djuro Miljanic, and Ivo Slaus, "Tito's Nuclear Legacy," *Bulletin of Atomic Scientists*, Vol. 56, No. 2 (March/April 2000).

1948: Yugoslavia's first nuclear research reactor center, the Vinca Institute of Nuclear Sciences, was established. See: Andrew Koch, "Yugoslavia's Nuclear Legacy: Should We Worry?," *Nonproliferation Review*, Vol. 4, No. 3 (Spring/Summer 1997), p. 123.

1948-50: Three more nuclear research centers were established. See William C. Potter, Djuro Miljanic and Ivo Slaus, "Tito's Nuclear Legacy," *Bulletin of Atomic Scientists*, Vol. 56, No. 2 (March/April 2000).

1953: A top-level strategy was prepared. Entitled "On Two Essential Conditions for the Development of Atomic Energy Here," the strategy identified "production of atomic weapons" as the first of two priorities for the atomic energy program. See William C. Potter, Djuro Miljanic, and Ivo Slaus, "Tito's Nuclear Legacy," *Bulletin of Atomic Scientists*, Vol. 56, No. 2 (March/April 2000).

1956: A Department for Spent Fuel Reprocessing was created at Vinca. See Andrew Koch, "Yugoslavia's Nuclear Legacy: Should We Worry?," *Nonproliferation Review*, Vol. 4, No. 3 (Spring/Summer 1997), p. 124.

1958: The first nuclear research reactor went critical at Vinca (RB), a heavy-water moderated reactor with a 250 kW capacity. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/15/2007>).

1959: A second nuclear research reactor went critical at Vinca (RA), a heavy-water moderated reactor with a capacity of 6.5 MWt. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/15/2007>).

Early 1960s: Tito deactivated the nuclear weapons program. See William C. Potter, Djuro Miljanic and Ivo Slaus, "Tito's Nuclear Legacy," *Bulletin of Atomic Scientists*, Vol. 56, No. 2 (March/April 2000).

1962: The Laboratory for Reactor Materials was created, where the capability to fabricate uranium oxide fuel elements for the RA research reactor was developed. See Andrew Koch, "Yugoslavia's Nuclear Legacy: Should We Worry?," *Nonproliferation Review*, Vol. 4, No. 3 (Spring/Summer 1997), p. 124.

1963: The uranium mine and mill were operational at Kalna. See Andrew Koch, "Yugoslavia's Nuclear Legacy: Should We Worry?," *Nonproliferation Review*, Vol. 4, No. 3 (Spring/Summer 1997), p. 124.

1966: A laboratory-scale PUREX plutonium reprocessing facility with four hot cells for reprocessing plutonium became operational at Vinca. The Kalna mining and milling operation was shut down, after Yugsoslavia had accumulated 900 kg of uranium dioxide (UO2) and 400 kg of uranium metal. See Andrew Koch, "Yugoslavia's Nuclear Legacy: Should We Worry?," *Nonproliferation Review*, Vol. 4, No. 3 (Spring/Summer 1997), p. 124.

1970: Yugoslavia ratified the NPT. See Federation of Atomic Scientists, "Weapons on Mass Destruction: Treaty on the Non-Proliferation of Nuclear Weapons," http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/15/2007>).

1973: A comprehensive safeguards agreement with the IAEA was ratified. See "Information Circulars," *International Atomic Energy Agency*, INFCIRC/1/Rev.14, May 2002, http://www.iaea.org/Publications/Documents/Infcircs/2002/infcirc1r14.pdf (accessed <8/15/2007>).

1974: Tito convened a top-secret meeting with the heads of the major nuclear research institutes and representatives from the military and intelligence services, and ordered them to use the country's nuclear power program as a camouflage for a parallel nuclear weapons program, deemed "Program A." See William C. Potter, Djuro Miljanic and Ivo Slaus, "Tito's Nuclear Legacy," *Bulletin of Atomic Scientists*, Vol. 56, No. 2 (March/April 2000).

1976: The Soviet Union supplied 48.2 kg of 80 percent enriched uranium fuel, in metal form, for the RA reactor. See Andrew Koch, “Yugoslavia’s Nuclear Legacy: Should We Worry?,” *Nonproliferation Review*, Vol. 4, No. 3 (Spring/Summer 1997), p. 126.

1978: The reprocessing research ended and the equipment was removed from the Vinca laboratories and placed under IAEA safeguards. These experiments may have resulted in the separation of between several grams and one kilogram of plutonium. See Andrew Koch, “Yugoslavia’s Nuclear Legacy: Should We Worry?,” *Nonproliferation Review*, Vol. 4, No. 3 (Spring/Summer 1997), p. 124.

1981: Yugoslavia’s first nuclear power plant became operational, in what is now Slovenia. See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/23/2007>).

1982: The Yugoslav Secretary of Defense forcefully promoted the nuclear weapons program. William C. Potter, Djuro Miljanic, and Ivo Slaus, “Tito’s Nuclear Legacy,” *Bulletin of Atomic Scientists*, Vol. 56, No. 2 (March/April 2000).

1980s: As Yugoslavia fractured and leadership in Belgrade changed, “Program A” lost support and effectively petered out. See William C. Potter, Djuro Miljanic, and Ivo Slaus, “Tito’s Nuclear Legacy,” *Bulletin of Atomic Scientists*, Vol. 56, No. 2 (March/April 2000).

1995: Macedonia acceded to the NPT. Serbia chose not to do so and has subsequently resisted doing so on the argument that it should be accepted as the sole successor to the Socialist Republic of Yugoslavia. See Federation of Atomic Scientists, “Weapons on Mass Destruction: Treaty on the Non-Proliferation of Nuclear Weapons,” http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/15/2007>).

2002: 48 kg of HEU was removed from Vinca Institute to the Russian Institute of Atomic Reactors. See Philipp C. Bleek, "Project Vinča: Lessons for Securing Civil Nuclear Material Stockpiles," *Nonproliferation Review*, Vol. 10, No. 3 (Fall-Winter 2003), p. 1.

2004: Serbia was approved by the IAEA board for ratification of the Additional Protocol. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/15/2007>).

Status in 2007: Serbia operates a single nuclear research reactor (RB) and has signed but not ratified the Additional Protocol. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/15/2007>) and http://www.iaea.org/DataCenter/index.html (accessed <8/15/2007>).

Slovakia

Czechoslovakia's first nuclear power reactor became operational in 1972 and in 1973 Czechoslovakia ratified the NPT, placing it in the Modest Weapons Potential category. In 1993 Slovakia became independent from Czechoslovakia and acceded to the NPT. In 2005 Slovakia ratified the Additional Protocol and at present maintains 5 nuclear power reactors.

Key timeline data:

1972: First nuclear power unit became operational in what was then Czechoslovakia. See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/23/2007>).

1973: Czechoslovakia ratified the NPT. See IAEA.org, "Country Profile: Slovakia," http://www.iaea.org/DataCenter/index.html (accessed <8/23/2007>).

1993: Czech Republic and Slovakia formalized their independent identities and acceded to the NPT. See Federation of Atomic Scientists, "Weapons on Mass Destruction: Treaty on the Non-Proliferation of Nuclear Weapons," http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/23/2007>).

1993: Slovakia ratified a comprehensive safeguards agreement with the IAEA . See IAEA.org, "Country Profile: Slovakia," http://www.iaea.org/DataCenter/index.html (accessed <8/23/2007>).

2005: The Additional Protocol was ratified. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/23/2007>).

Status in 2007: Slovakia operates five nuclear power reactors under full-scope IAEA safeguards. It has also ratified the CTBT. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Slovak.pdf (accessed <8/23/2007>).

Slovenia

Yugoslavia ratified the NPT in 1970. Its first nuclear power reactor became operational in 1981, placing Yugoslavia in the Modest Weapons Potential category. In 1991 Slovenia became independent from Yugoslavia, and in 1993 it acceded to the NPT. In 2006 Slovenia ratified the Additional Protocol. As of 2007 Slovenia maintains 1 nuclear power reactor.

Key timeline data:

1970: Yugoslavia ratified the NPT. See Federation of Atomic Scientists, "Weapons on Mass Destruction: Treaty on the Non-Proliferation of Nuclear Weapons," http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/23/2007>).

1981: Yugoslavia's first nuclear power reactor became operational. See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/23/2007>).

1991: Slovenia became independent from Yugoslavia.

1993: Slovenia acceded to the NPT. See Federation of Atomic Scientists, "Weapons on Mass Destruction: Treaty on the Non-Proliferation of Nuclear Weapons," http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/23/2007>).

1997: A comprehensive safeguards agreement with the IAEA was ratified. See IAEA.org, "Country Profile: Slovenia," http://www.iaea.org/DataCenter/index.html (accessed <8/23/2007>).

2006: The Additional Protocol was ratified. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/23/2007>).

Status in 2007: Slovenia operates a single nuclear power reactor under IAEA safeguards. See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/23/2007>).

Spain

Spain's first nuclear research reactor (Coral-1) went critical in 1959. This placed Spain in the Nil Weapons Potential category. It moved into the Modest Weapons Potential Category in 1968 when its first nuclear power reactor went critical. In 1968 Spain also declined to sign the NPT. In 1969 weapons-grade plutonium was created at the Coral-1 experimental reactor. In 1971 a feasibility study of nuclear weapons development was authorized; it concluded that Spain possessed the needed technology. Franco's death in 1975 led to abandonment of the nuclear weapons program. Spain ratified the NPT in 1987 and the Additional Protocol in 2004. As of 2007 Spain maintains eight nuclear power reactors.

Key timeline data:

1958: First nuclear research reactor went critical (Coral-1). See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/13/2007>).

1961: Second nuclear research reactor went critical. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/13/2007>).

1962: Third nuclear research reactor went critical. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/13/2007>).

1960s: Suspicions arose that the military dictatorship had begun to develop nuclear weapons facilities. PBS.org, "Tracking Nuclear Proliferation: Spain," http://www.pbs.org/newshour/indepth_coverage/military/proliferation/countries/spain.html (accessed <8/13/2007>).

1963: Spain conducted its first feasibility study of the possibility for the development of nuclear weapons. The study concluded that the technical means to execute such a program were missing. See Juan C. and Vicente Garrido, "History: Spain, Nuclear Power," *El Mundo* No. 295, 10 June 2001, www.elmundo.es/cronica/2001/CR295/CR295-12.html (accessed <8/13/2007>).

1966: The US lost a hydrogen bomb warhead off the Spanish coastline in the Palomares incident.

1968: Spain's first nuclear power reactor went critical. See IAEA Power Reactor Information System, http://www.iaea.or.at/programmes/a2/ (accessed <8/13/2007>).

1968: Spain declined to sign the NPT. See PBS.org, "Tracking Nuclear Proliferation: Spain," http://www.pbs.org/newshour/indepth_coverage/military/proliferation/countries/spain.html (accessed <8/13/2007>).

1969: Weapons grade plutonium was created at the Coral-1 experimental reactor. See Juan C. and Vicente Garrido, "History: Spain, Nuclear Power," *El Mundo* No. 295, 10 June 2001, www.elmundo.es/cronica/2001/CR295/CR295-12.html (accessed <8/13/2007>).

1971: Spain authorized a second feasibility study, this one leading to an assessment that the technical means had become available. See Juan C. and Vicente Garrido, "History: Spain, Nuclear Power," *El Mundo* No. 295, 10 June 2001, www.elmundo.es/cronica/2001/CR295/CR295-12.html (accessed <8/13/2007>).

1975: Military dictator Francisco Franco died and the nuclear weapons program was abandoned. See PBS.org, "Tracking Nuclear Proliferation: Spain," http://www.pbs.org/newshour/indepth_coverage/military/proliferation/countries/spain.html (accessed <8/13/2007>).

1980s: Spain built nuclear power units. See IAEA.org, "Country Profile: Spain," http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

1987: The NPT was ratified. See Federation of Atomic Scientists, "Weapons on Mass Destruction: Treaty on the Non-Proliferation of Nuclear Weapons," http://www.fas.org/nuke/control/npt/text/npt3.htm (accessed <8/7/2007>).

1989: A comprehensive safeguards agreement with the IAEA was ratified. See IAEA.org, "Country Profile: Spain," http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

1993: Uranium mining operations began. See *Country Nuclear Fuel Cycle Profiles*, 2nd edition, International Atomic Energy Agency, Technical Reports Series No 425 (Vienna: IAEA, 2005), p. 77.

2002: Uranium mining operations terminated. See *Country Nuclear Fuel Cycle Profiles*, 2nd edition, International Atomic Energy Agency, Technical Reports Series No 425 (Vienna: IAEA, 2005), p. 77.

2004: The Additional Protocol was ratified. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

Status in 2007: Spain operates 8 nuclear power reactors under full-scope IAEA safeguards. It also has an indigenous fuel fabrication capability. It has ratified the CTBT. See http://www.reachingcriticalwill.org/about/pubs/Inventory07/Spain.pdf (accessed <8/13/2007>).

Sweden

Sweden created a nuclear authority, Atomenergi, in 1949, with the intent to exploit its uranium deposits for both civilian and military purposes, and in 1952 Sweden's Defense Research Establishment (FOA) began research on nuclear weapons. These developments placed Sweden in the Nil Weapons Potential category. Its first nuclear research reactor, the R-1, went critical in 1954. Its third research reactor, the R-3 Agesta, was designed to produce both electricity and a small stock of fissile materials for possible weaponization in time of crisis, and it went operational in 1958, in advance of the R-2 reactor. This moved Sweden into the Modest Weapons Potential category. By 1961 Sweden, in violation of an agreement with the US, had the hypothetical capability to remove fissile material for its reactors and fashion it into a crude nuclear device. This moved Sweden into the High Weapons Potential category. However, in 1963 the FOA decided not to conduct criticality experiments, a vital element in the development of nuclear weapons. In 1970 Sweden ratified the NPT. By 1974 it had disassembled all of its plutonium facilities (R-3), and these actions combined to move Sweden down into the Modest Weapons Potential category. In 2004 Sweden ratified the Additional Protocol. As of 2007 Sweden maintains 10 nuclear power reactors.

Key timeline data:

1949: Sweden established a nuclear authority, Atomenergi. Its purpose was to exploit Sweden's uranium deposits to produce fissile materials for both power generation and a possible future weapons program. See T.V. Paul, *Power Versus Prudence: Why States Forgo Nuclear Weapons* (Montreal: McGill-Queen's University Press, 2000), p. 87.

1952: The FOA began research on nuclear weapons. See T.V. Paul, *Power Versus Prudence: Why States Forgo Nuclear Weapons* (Montreal: McGill-Queen's University Press, 2000), p. 87.

1954: Sweden's first nuclear research reactor, the R-1 (supplied with Norwegian heavy-water), went critical. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/13/2007>).

1956: Sweden's second nuclear research reactor, the R-2, was purchased from the US under bilateral safeguards. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/13/2007>).

1956: Sweden acquired a third nuclear research reactor, the R-3 Agesta, which was designed to both produce electricity and weapons material for possible use in military crisis. See Eric Arnett, "Norms and Nuclear Proliferation: Sweden's Lessons for Assessing Iran," *Nonproliferation Review*, Vol. 5, No. 2 (Winter 1998), p. 36.

1957: The FOA suggested using the R-3 Agesta reactor to produce a small number of nuclear weapons quickly, by 1960 if necessary, as an interim capability pending the expected start-up in 1968 of the R-4 Markiven reactor, which was designed to produce a quantity of fissile material sufficient to support a stockpile of 100 nuclear weapons. See Eric Arnett, "Norms and Nuclear Proliferation: Sweden's Lessons for Assessing Iran," *Nonproliferation Review*, Vol. 5, No. 2 (Winter 1998), p. 36.

1958: The Defense Minister directed FOA to shift its emphasis in favor of defensive research. See Eric Arnett, "Norms and Nuclear Proliferation: Sweden's Lessons for Assessing Iran," *Nonproliferation Review*, Vol. 5, No. 2 (Winter 1998), p. 36.

1958: The R-3 Agesta reactor became operational, in advance of the R-2 reactor, and began to produce plutonium. See M. D. Zentner, G. L. Coles, and R. J. Talbert, "Nuclear Proliferation Technology Trends Analysis," Pacific Northwest National Laboratory, PNNL-14480 (September 2005), p. 81.

1960: The R-2 reactor went critical. See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/13/2007>).

1961: By this time Sweden had the hypothetical capability to remove the fissile material from the R-2 reactor and fashion it into a crude nuclear device. See Eric Arnett, "Norms and Nuclear Proliferation: Sweden's Lessons for Assessing Iran," *Nonproliferation Review*, Vol. 5, No. 2 (Winter 1998), p. 36.

1963: The FOA decided not to conduct criticality experiments. See Eric Arnett, "Norms and Nuclear Proliferation: Sweden's Lessons for Assessing Iran," *Nonproliferation Review*, Vol. 5, No. 2 (Winter 1998), p. 36.

1968: Sweden's leaders officially renounced nuclear weapons. See T.V. Paul, *Power Versus Prudence: Why States Forgo Nuclear Weapons* (Montreal: McGill-Queen's University Press, 2000), p. 88.

1970: The NPT was ratified. See IAEA.org, "Country Profile: Sweden," http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

1972: The FOA terminated its research on the plutonium it had acquired. See Source: Eric Arnett, "Norms and Nuclear Proliferation: Sweden's Lessons for Assessing Iran," *Nonproliferation Review*, Vol. 5, No. 2 (Winter 1998), p. 36.

1974: Disassembly of all plutonium facilities (R-3) was concluded. See Eric Arnett, "Norms and Nuclear Proliferation: Sweden's Lessons for Assessing Iran," *Nonproliferation Review*, Vol. 5, No. 2 (Winter 1998), p. 37.

1995: A comprehensive safeguards agreement with the IAEA was ratified. See IAEA.org, "Country Profile: Sweden," http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

2004: The Additional Protocol was ratified. See IAEA.org, http://www.iaea.org/DataCenter/index.html (accessed <8/13/2007>).

Status in 2007: Sweden operates 10 nuclear power units and has a fuel fabrication facility, all under full-scope safeguards. It has also ratified the CTBT. See :http://www.reachingcriticalwill.org/about/pubs/Inventory07/Sweden.pdf (accessed <8/13/2007>).

Switzerland

In 1945 Switzerland's Atomic Energy Committee was given the mandate to investigate defensive protective measures for the country and to determine what would be required to develop nuclear weapons. In 1958 Switzerland's Federal Council of Ministers instructed the Federal Military Department (EMD) to investigate the effects, acquisition, purchase, and manufacture of nuclear arms. In 1960 Switzerland's first nuclear research reactor went critical (heavy-water). These developments placed Switzerland in the Nil Weapons Potential category. By 1963 Switzerland's nuclear weapons planning had proceeded to detailed technical proposals, specific arsenals, and cost estimates, and in 1964 the joint staff of the military issued a recommendation to create a force of approximately 100 nuclear bombs. But Swiss political leaders chose not to make the commensurate fiscal investment. In 1969 Switzerland ratified the NPT and its first nuclear power reactor became operational, moving the country to the Modest Weapons Potential category. In 2005 Switzerland ratified the Additional Protocol. As of 2007 Switzerland maintains five nuclear power units and three research reactors.

Key timeline data:

1945: The Swiss Atomic Energy Committee was given the mandate to investigate defensive protective measures for the country and to determine what would be required to develop nuclear weapons. See T.V. Paul, *Power Versus Prudence: Why States Forgo Nuclear Weapons* (Montreal: McGill-Queen's University Press, 2000), p. 92.

1957: The head of the General Staff commissioned a study concerning the possible acquisition of nuclear arms. The study recommended the acquisition. See Nuclear Weapons Archive, "Switzerland," http://nuclearweaponarchive.org/Nwfaq/Nfaq7-4.html#switzerland (accessed <8/14/2007>).

1958: The Swiss Federal Council of Ministers instructed the EMD to investigate the effects, acquisition, purchase, and manufacture of nuclear arms. See T.V. Paul, *Power Versus Prudence: Why States Forgo Nuclear Weapons* (Montreal: McGill-Queen's University Press, 2000), p. 94.

1960: The first nuclear research reactor went critical (heavy-water). See IAEA Research Reactor Data Base, http://www.iaea.or.at/worldatom/rrdb/ (accessed <8/14/2007>).

1963: Nuclear weapons planning had proceeded to detailed technical proposals, specific arsenals, and cost estimates. See Nuclear Weapons Archive, "Switzerland," http://nuclearweaponarchive.org/Nwfaq/Nfaq7-4.html#switzerland (accessed <8/14/2007>).

1964: The Swiss military staff recommended that Switzerland create a nuclear force of approximately 100 nuclear bombs. See T.V. Paul, *Power Versus Prudence: Why States Forgo Nuclear Weapons* (Montreal: McGill-Queen's University Press, 2000), p. 95.

1964: Financial problems with the defense budget prevented the investment of the substantial sums deemed necessary to the recommended force. See Nuclear Weapons Archive, "Switzerland," http://nuclearweaponarchive.org/Nwfaq/Nfaq7-4.html#switzerland (accessed <8/14/2007>).

1969: Switzerland ratified the NPT. See IAEA.org, "Country Profile: Switzerland," http://www.iaea.org/DataCenter/index.html (accessed <8/14/2007>).

1969: A Working Committee for Nuclear Issues was created (and met 27 times between 1969 and 1988). See Nuclear Weapons Archive, "Switzerland," http://nuclearweaponarchive.org/Nwfaq/Nfaq7-4.html#switzerland (accessed <8/14/2007>).

1978: A comprehensive safeguards agreement with the IAEA was ratified. See IAEA.org, "Country Profile: Switzerland," http://www.iaea.org/DataCenter/index.html (accessed <8/14/2007>).

1988: The Working Committee for Nuclear Issues was dissolved. See Nuclear Weapons Archive, "Switzerland," http://nuclearweaponarchive.org/Nwfaq/Nfaq7-4.html#switzerland (accessed <8/14/2007>).

2005: The Additional Protocol was ratified. See IAEA.org, "Country Profile: Switzerland," http://www.iaea.org/DataCenter/index.html (accessed <8/14/2007>).

Status in 2007: Switzerland operates five nuclear power units and three research reactors under comprehensive safeguards. It has ratified the CTBT. See: http://www.reachingcriticalwill.org/about/pubs/Inventory07/Switzerlandpdf (accessed <8/14/2007>).

Ukraine

With the collapse of the USSR in 1991, Ukraine inherited between 4,500 and 6,000 or more nuclear weapons. This placed Ukraine in the Potential for Serial Weapons Production category. By February 1993 about half of the 2,200 tactical nuclear weapons stationed in the country had been transferred to Russia, and by May the last of the tactical weapons had been transferred to Russia. In December 1994 Ukraine ratified the NPT. In 1996 the last nuclear weapons were transferred to Russia, moving Ukraine into the Modest Weapons Potential Category. In 2006 Ukraine ratified the Additional Protocol. As of 2007 Ukraine maintains 24 nuclear power reactors and plans to construct new fuel cycle facilities with the exception of enrichment plants by 2010.

Key timeline data:

1991: The Soviet Union collapsed and Ukraine inherited from 4,500 to 6,000 or more nuclear weapons. The new government expressed its view that Ukraine should "have the status of a non-nuclear state." See Joseph Cirincione, Jon B. Wolfsthal and Miriam Rajkumar, *Deadly Arsenals Nuclear, Biological, and Chemical Threats* 2nd edition (Washington D.C.: Carnegie Endowment for International Peace, 2005), p. 373.

1992: Ukraine signed the Lisbon Protocol. By February about half of the 2,200 tactical nuclear weapons stationed in the country had been transferred to Russia. By May the last of the tactical weapons had been transferred to Russia. See Mark D. Skootsky, "An Annotated Chronology of Post-Soviet Nuclear Disarmament 1991-1994," *Nonproliferation Review*, Vol. 2, No. 3 (Summer/Spring 1995), pp. 69-70.

1993: US intelligence warned that Ukraine was attempting to gain control of the SS-24 ICBMs on its territory by rewriting the computer-codes. The Ukrainian Rada passed a new defense doctrine in which the strategic nuclear weapons on its territory were considered Ukrainian property. Ukraine's president stated that START I did not include Ukraine's 46 SS-24 ICBMs and that Ukraine would keep the missiles following the ratification of the treaty. See Mark D. Skootsky, "An Annotated Chronology of Post-Soviet Nuclear Disarmament 1991–1994," *Nonproliferation Review*, Vol. 2, No. 3 (Summer/Spring 1995), p. 74.

1994: START I was ratified in February. Ratification of the NPT is delayed repeatedly until December. See Mark D. Skootsky, "An Annotated Chronology of Post-Soviet Nuclear Disarmament 1991-1994," *Nonproliferation Review*, Vol. 2, No. 3 (Summer/Spring 1995), p. 80.

1996: The transfer of nuclear weapons was concluded. See Nuclear Weapons Archive, "Ukraine," http://nuclearweaponarchive.org/Nwfaq/Nfaq7-4.html#ukraine (accessed <8/14/2007>).

2006: The Additional Protocol was ratified. See IAEA.org, "Country Profile: Ukraine," http://www.iaea.org/DataCenter/index.html (accessed <8/14/2007>).

Status in 2007: Ukraine operates 24 nuclear power reactors under IAEA safeguards. It also has a mining and milling capacity and plans to construct new fuel cycle facilities (with the exception of enrichment plants) by 2010. Ukraine has ratified the CTBT. See Nuclear Weapons Archive, "Ukraine," http://nuclearweaponarchive.org/Nwfaq/Nfaq7-4.html#ukraine (accessed <8/14/2007>) and http://www.reachingcriticalwill.org/about/pubs/Inventory07/Ukraine.pdf (accessed <8/14/2007>).

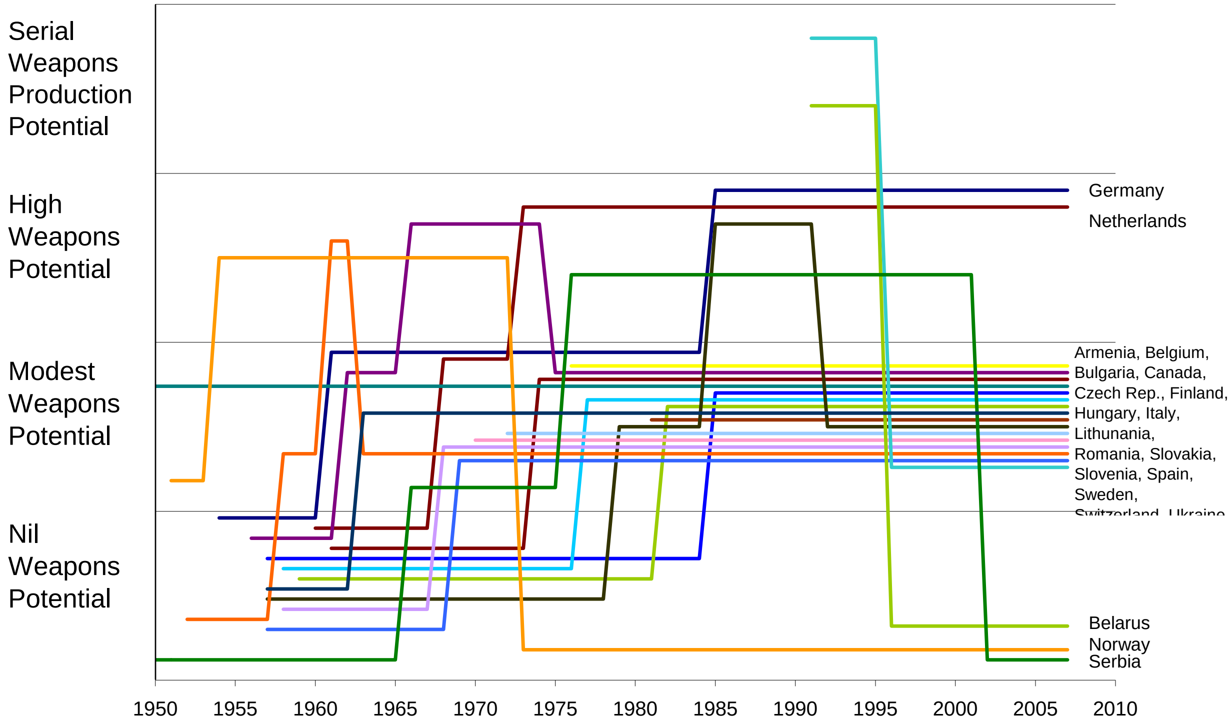

Figure 5. Europe's Nuclear Proliferation History

F. TREND ANALYSES

Working with the historical data for each of the global regions, we were able to compile some additional graphics that provide useful insights into special cases and trends in proliferation.

A detailed summary of historical experience follows in figure 6. This is a compilation of all of the experience of the regions into a single global, historical view.

Figure 7 illustrates the four cases in which nonproliferation efforts have failed to prevent states from achieving a potential for serial weapons production.

Figure 8 illustrates the six cases in which nonproliferation efforts have succeeded in moving states with nuclear weapons or significant weapons ambitions and potential to a non-weapons status and otherwise reduced capability.

The next three figures illustrate the fact that at least twice in nuclear history a significant potential for a cascade of nuclear proliferation has been successfully managed. Figure 9 explores the period from the advent of broad nuclear interest in the 1960s through the successful conclusion of the NPT and the decision by many states to abandon weapons ambitions or to accept a degree of latent capability in lieu of standing capability (perhaps in conjunction with security guarantees of one form or another). Figure 10 is a subset of the states in figure 9—those for which there is now some clear evidence that they launched their nuclear activities with an intention to create an arsenal of nuclear weapons, as opposed to simply develop a latent potential. This figure illustrates how nearly all of them settled for something less or different. Figure 11 explores the period from the mid-1970s, when a looming crisis of confidence in US security guarantees in East Asia post-Vietnam led many states to step up their weapons potential. This period concluded with some significant capability reductions in the early 1990s.

Figure 12 maps out the period from the end of the early 1990s to the present—a period not noteworthy for a rapid and widespread growth in weapons potential.

Figures 11 and 12 include only those states that increased or decreased their nuclear capabilities within the specified period, or actually started a program. Those that remained in a steady state are not depicted. Take Japan as an example. During the period from 1950 to 1974, Japan increases its nuclear capabilities and rose to the High Weapons Potential Category, as reflected on the graphic. But its status has not changed since 1969, so it is not reported as steady-state in the charts for later periods.

Figure 13 illustrates additional forms of successful nonproliferation and rollback beyond those in figure 8. It is a selective use of data from the comprehensive historical summary (figure 6) which includes only that data related to actions by states to reduce capabilities by relinquishing elements of the fuel cycle or other access to fissile material, by closing down design and engineering facilities, and/or by accepting increasingly stringent safeguards. A brief analytical summary of the data accompanies this figure.

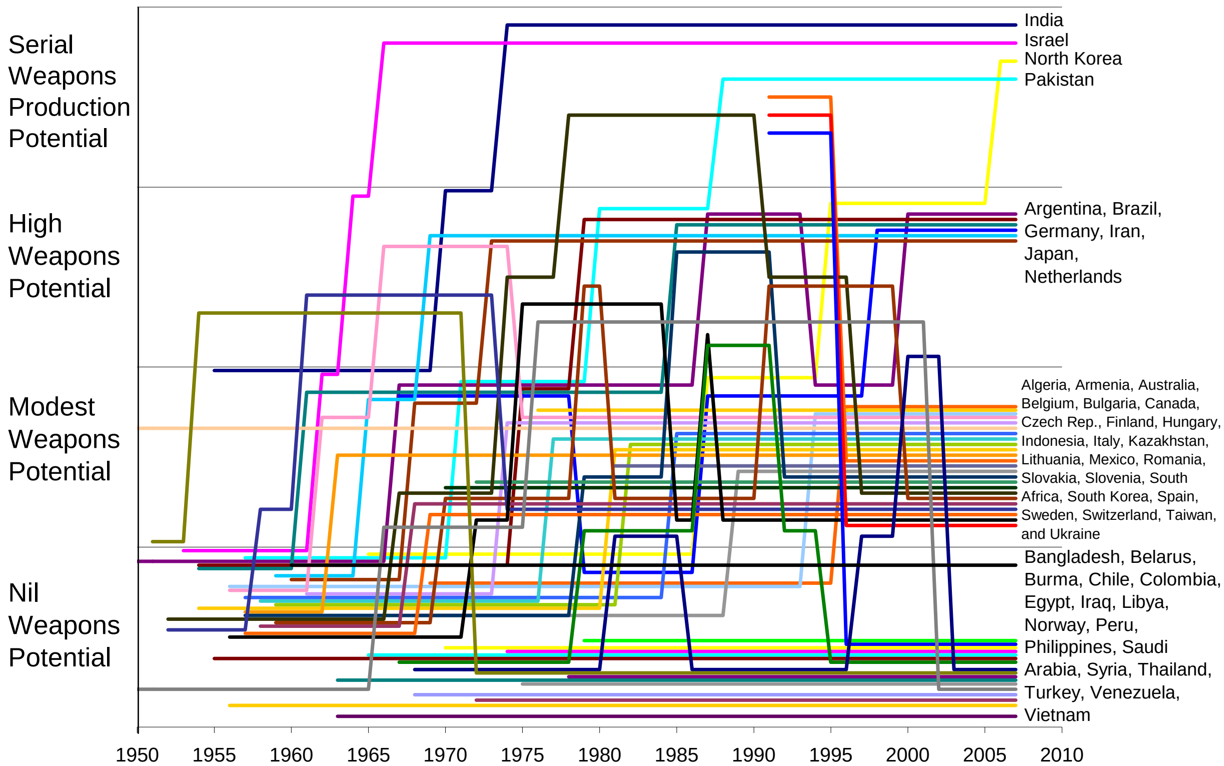

Figure 6. A Comprehensive View of the History of Nuclear Proliferation

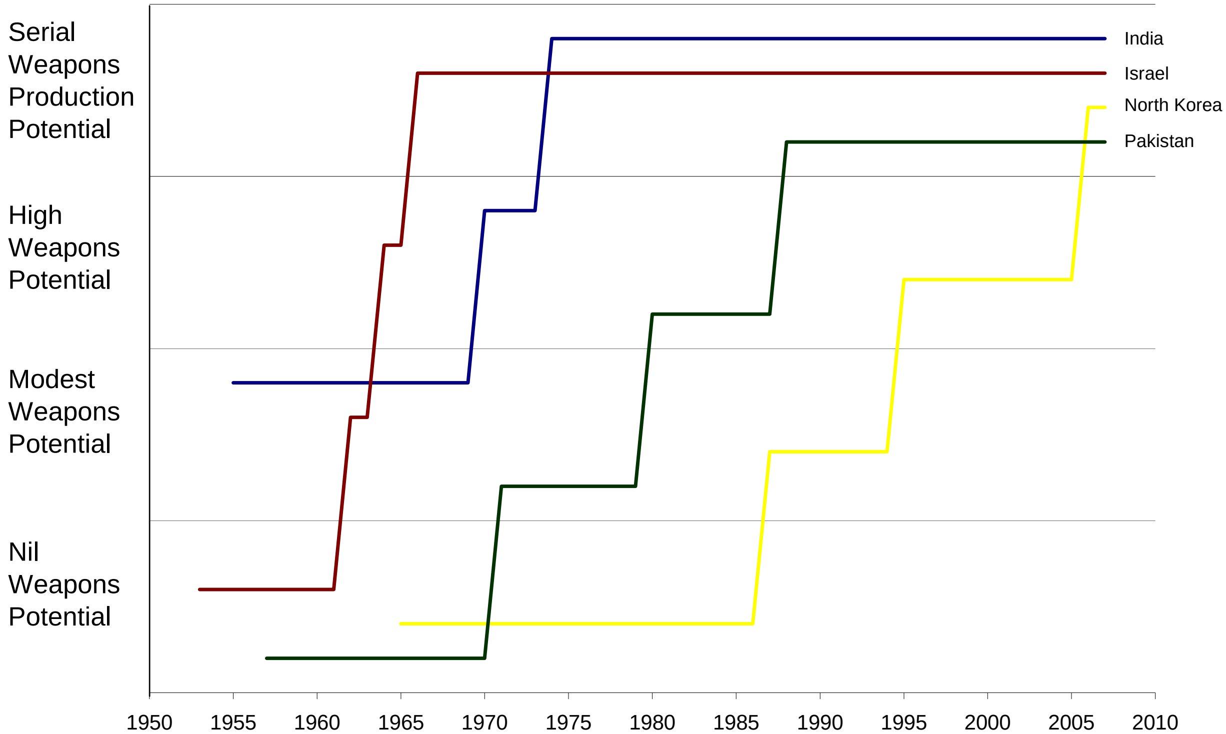

Figure 7. Nonproliferation Failures

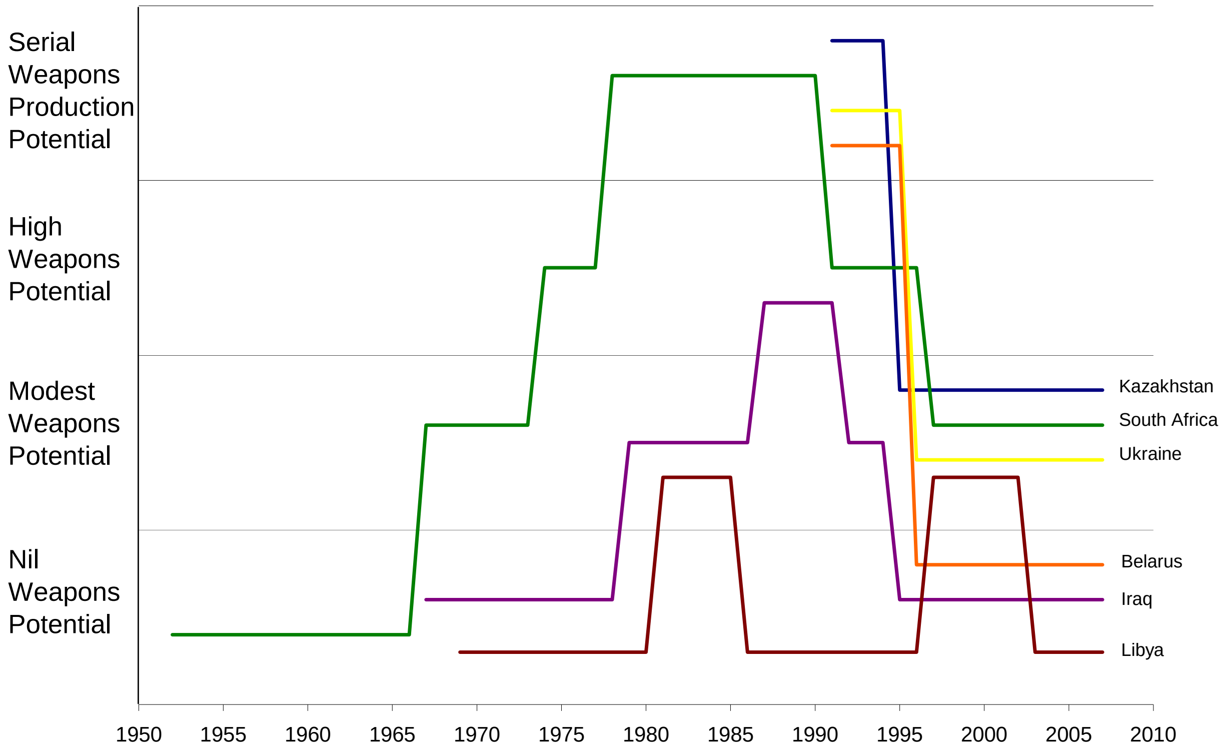

Figure 8. Nonproliferation Successes

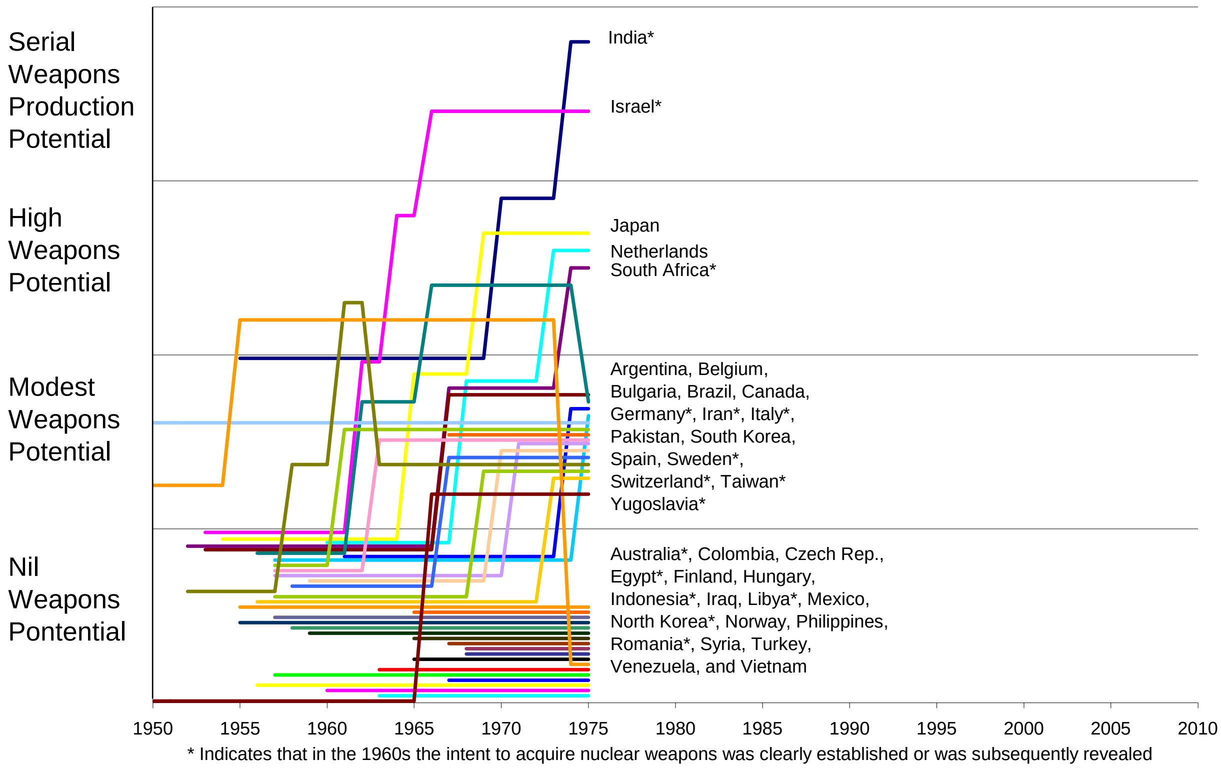

Figure 9. The First Potential Tipping Point in the 1960s

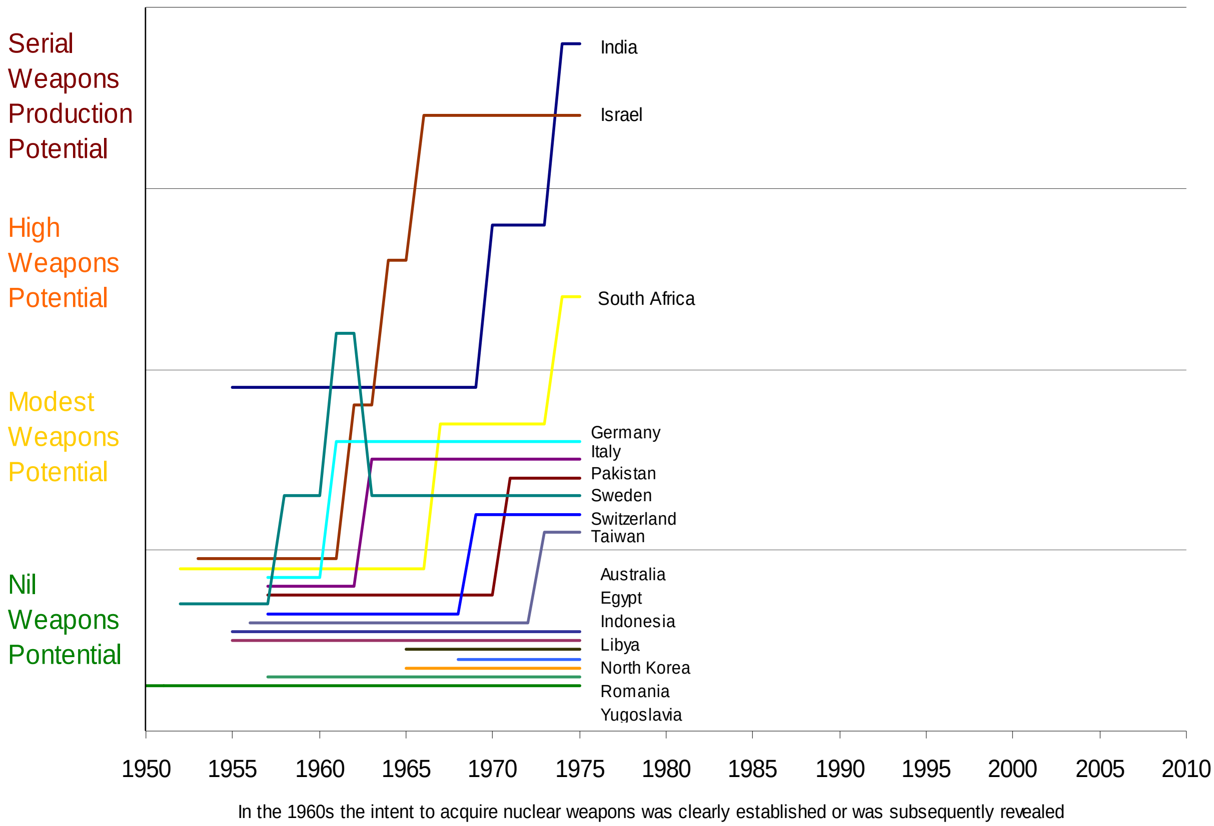

Figure 10. Success in Preventing the First Potential Cascade

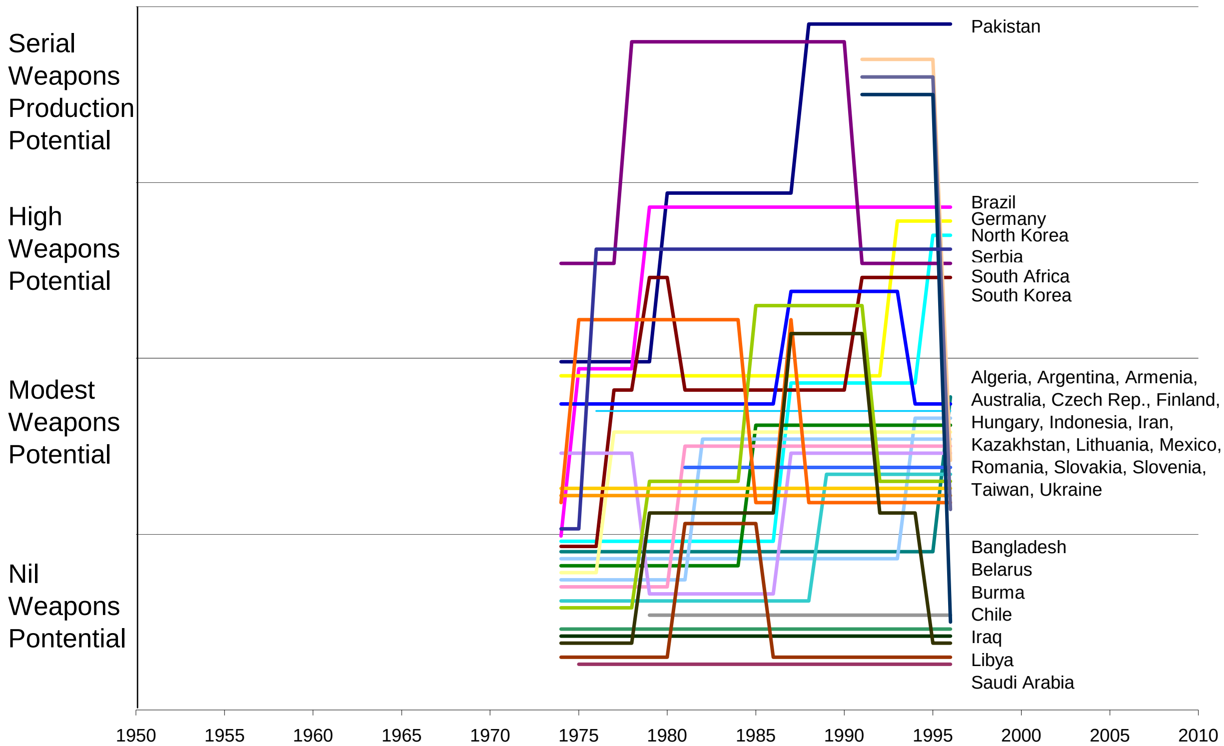

Figure 11. The Second Potential Tipping Point in the 1970s and 1980s

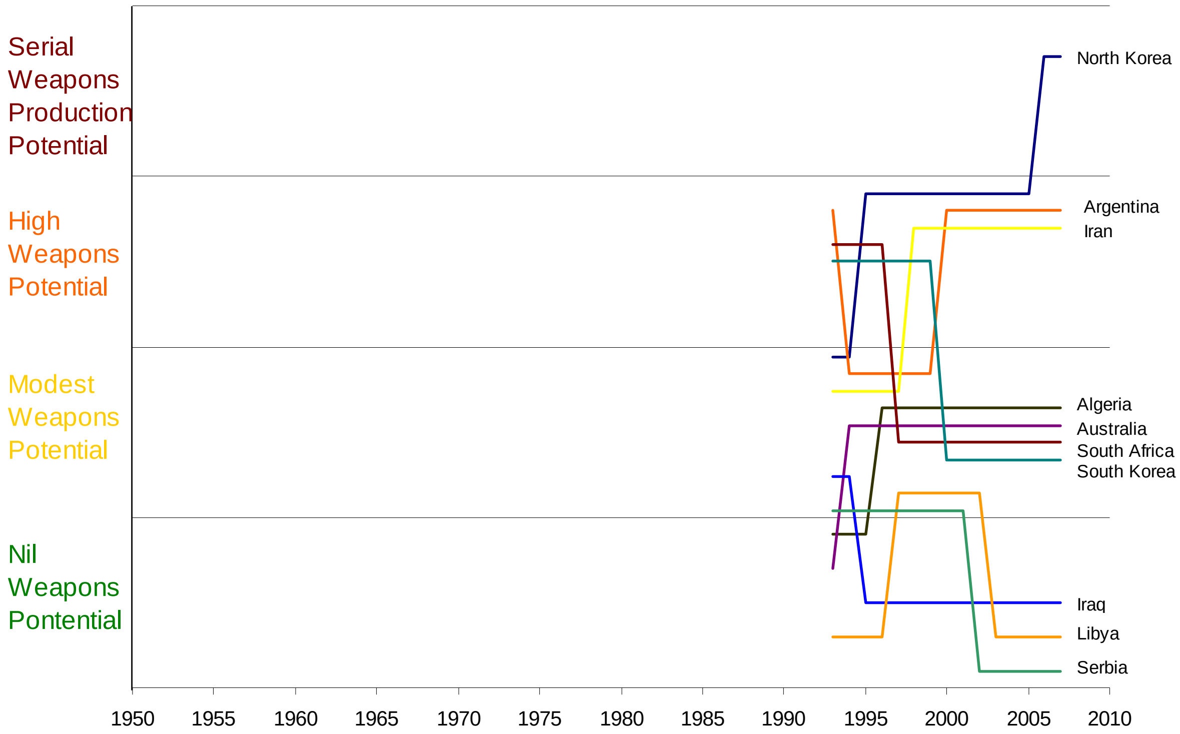

Figure 12. Toward A New Tipping Point?

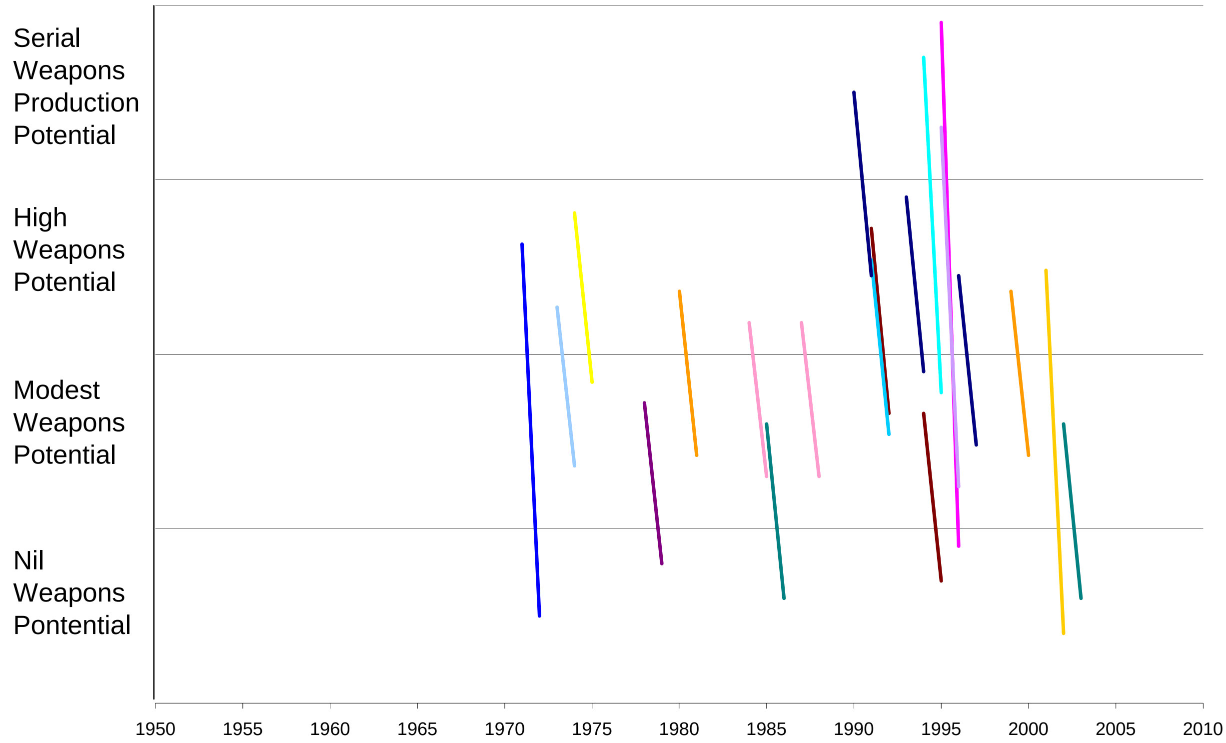

Figure 13: Additional Forms of Rollback Success

Figure 13 merits a fuller explanation. It details the instances we have identified here in which a state took steps to decrease its technical capabilities for the production of nuclear weapons—what some have called "nuclear rollback." This graphic illustrates the important lesson that proliferation is neither inevitable nor irreversible. Each rollback is explained below. The data are reported within each decade by year and country, in combination with a brief explanation of the decision or other factor that reduced capability or interrupted an effort underway to move up the capability ladder.

<u>1970s</u>

1972: Norway's small-scale plutonium separation experiments ended (in the early 1970s), and it ratified a comprehensive safeguards agreement with the IAEA in 1972.

1974 Sweden became a signatory of the NPT and disassembled all of its plutonium facilities.

1975: Belgium's PUREX reprocessing facility was shut down.

1979: The Iranian Revolution interrupted construction at Bushehr, and even though it did not remove the established science and technology base, most nuclear activities ceased..

1980s

1981: South Korea's chemical enrichment experiments were concluded but no further steps were taken.

1985: The US and Taiwan reached an agreement to return to the US all of the spent fuel from the research reactor, thus curtailing Taiwan's access to fissile material.

1986: Libya's budding nuclear program was put under additional US sanctions, thereby cutting off its access to nuclear-related materials and technology. At the same time, Libya's collaborative partnership with Pakistan atrophied, cutting off access to nuclear know-how.

1988: After significant US pressure, Taiwan shut down its hot cell facility and agreed to return remaining heavy water to the US and to ban any weapons-related nuclear research.

1990s

1991: South Africa's President F.W. de Klerk ordered the termination of South Africa's nuclear weapons program, and South Africa acceded to the Nuclear Non-Proliferation Treaty as a non-nuclear state.

1992: The Iraq War and subsequent actions brought destruction of the Al Atheer, Al Tarmiya, and Tuwaitha (EMIS) facilities.

1992: The Romanian government discovered the previously undeclared and un-safeguarded separated plutonium, reported its discovery to the IAEA, and agreed to full IAEA inspections and control of its facilities

1994: Argentina's gaseous diffusion enrichment facility was shut down.

1995: Iraq's Hussein Kamel defected, revealing previously undisclosed portions of the program, including the 1990 crash extraction program, enabling IAEA inspectors to fully disable the vast majority if not all of Iraq's nuclear facilities.

1995: Kazakhstan completed the removal of the strategic nuclear weapons on its territory to Russia.

1996: Belarus completed the removal of nuclear warheads to Russia.

1996: Ukraine's transfer of nuclear weapons to Russia was concluded.

1997: South Africa's enrichment facilities were permanently closed.

<u>2000s</u>

2000: South Korea's AVLIS uranium enrichment experiments ended.

2002: Serbia transferred 48 kg of HEU from the Vinca Institute to the Russian Institute of Atomic Reactors.

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13. SUPPLEMENTARY NOTES

14. ABSTRACT

A great deal of analysis has focused on the intentions of nuclear proliferators. Instead, this analysis focuses on capabilities. Our purpose is to understand how individual countries have developed their technical potential to produce nuclear weapons. The analysis reported here surveys the experience of 52 countries over 57 years as they have taken steps to develop nuclear related technical capabilities. For each country, key decision points in the development of those capabilities have been gathered, catalogued, and referenced. Those decisions relate to three key attributes: access to fissile material, weapons design and engineering, and treaty status. Each attribute has a spectrum of capability associated with it. The actual technical potential of a country to produce nuclear weapons is a function of its place on these spectrums. As further explained in the body of the report, we distinguish four basic levels of weapons potential: nil, modest, high, and "for serial production."

15. SUBJECT TERMS

Nuclear proliferation, South America, the Middle East, Asia, Europe, nuclear weapons, fissile material

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