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Abstract


Nathan Edward Busch, Department of Political Science, University of Toronto

This dissertation focuses on the current debate in international relations literature over the risks associated with the proliferation of nuclear weapons. On this subject, IR scholars are divided into roughly two schools: proliferation "optimists," who argue that proliferation can be beneficial and that its associated hazards are at least surmountable, and proliferation "pessimists," who believe the opposite. This debate centers upon a theoretical disagreement about how best to explain and predict the behavior of states. Optimists generally ground their arguments on rational deterrence theory and maintain that nuclear weapons can actually increase stability among states, while pessimists often ground their arguments on "organization theory," which contends that organizational, bureaucratic, and other factors prevent states from acting rationally. A major difficulty with the proliferation debate, however, is that both sides tend to advance their respective theoretical positions without adequately supporting them with solid empirical evidence. This dissertation bridges the gap between abstract theory and empirical evidence by conducting detailed analyses of the nuclear programs in the United States, Russia, China, India, and Pakistan to determine whether countries with nuclear weapons have adequate controls over their nuclear arsenals and fissile material stockpiles (such as highly enriched uranium and plutonium). These case studies identify the strengths and weaknesses of different systems of nuclear controls and help predict what types of controls proliferating states are likely to employ. On the basis of the evidence gathered from these cases, this dissertation concludes that a further spread of nuclear weapons would tend to have seriously negative effects on international stability by increasing risks of accidental, unauthorized, or inadvertent use of nuclear weapons and risks of thefts of fissile materials for use in nuclear or radiological devices by aspiring nuclear states or terrorist groups.
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Abbreviations and Acronyms

The following is a list of all the acronyms used in this dissertation. I have also defined each acronym the first time it appears in every chapter.

3 I's: Isolation, Incompatibility, Inoperability
3 G's: Guards, Gates, and Guns
ABM: Anti-Ballistic Missile System (and Treaty)
ADM: Atomic Demolition Munitions
AEC: Atomic Energy Commission (U.S.)
AEC: Atomic Energy Commission (India)
AERB: Atomic Energy Regulatory Board (India)
AFB: Air Force Base
AMAC: Aircraft Monitoring and Control (U.S.)
ASW: Anti-Submarine Weapon (Russia)
BARC: Bhabha Atomic Research Centre (India)
BCSS: Bomber Coded Switch System (U.S.)
BJP: Bharatiya Janata Party (India)
BMEWS: Ballistic Missile Early-Warning System
C^2: Command and Control
C^3I: Command, Control, Communications, and Intelligence
C^4I: Command, Control, Communications, Computers, and Intelligence
CAEA: China Atomic Energy Agency
CAEP: China Academy of Engineering Physics
CANDU: Canada Deuterium Uranium reactor
CBMs: Confidence Building Measures
CCD: Coded Control Device (U.S.)
CCP: Chinese Communist Party
CCTV: Close-Circuit Television
CHASNUPP: Chasma Nuclear Power Plant (Pakistan)
CHEGET: Russia’s “nuclear suitcase”
CINC: Commander-in-Chief
CINCNORAD: Commander-in-Chief, NORAD (U.S.)
CLL: U.S.-China Lab-to-Lab Collaborative Program
CNNC: China National Nuclear Corporation
CSS: NATO designation for Chinese nuclear missiles
CTBT: Comprehensive Test Ban Treaty
CTR: Cooperative Threat Reduction (or Nunn-Lugar Program)
DAE: Department of Atomic Energy (India)
DCC: Development Control Committee (Pakistan)
DF: Dong Feng or “East Wind” (missile) (China)
DOD: Department of Defense (U.S.)
DOE: Department of Energy (U.S.)
DSP: Defense Support Program (a satellite early-warning system, U.S.)
ECC: Employment Control Committee (Pakistan)
ENDS: Enhanced Nuclear Detonation Safety (U.S.)
ERDA  Energy Research and Development Administration (U.S.)
ESD   Environmental Sensing Device (U.S., Russia)
FARR  Fail-Safe and Risk Reduction commission (U.S.)
FRP   Fire Resistant Pits (U.S.)
GAN   Gosatomnadzor (Russian)
GAO   General Accounting Office (U.S.)
GLSV  Geosynchronous Satellite Launch Vehicle (India)
H-6   Hong-6 bomber (China)
HE    High Explosive
HEU   Highly Enriched Uranium
IAEA  International Atomic Energy Agency
IAEC  India Atomic Energy Commission
IAPCM Institute of Applied Physics and Computational Mathematics (China)
ICBM  Intercontinental Ballistic Missile
IFI   In-Flight Insertion component (U.S.)
IHE  Insensitive High Explosive
INF   Intermediate-Range Nuclear Forces treaty (U.S.-Russia)
INFCIRC Information Circular (IAEA)
K-26  Krasnoyarsk-26 (Russia)
KANUPP Karachi Nuclear Power Plant (Pakistan)
KGB   Committee for State Security (Soviet/Russian)
KMP   Key Measurement Points
LANL  Los Alamos National Laboratory (U.S.)
LCC   Dual Launch Control System (U.S.)
LDS   Launch-Detection System (U.S. designation for the Russian system)
LEU   Low Enriched Uranium
LLNL  Lawrence Livermore National Laboratory (U.S.)
LOC   Line of Control (India-Pakistan)
LOW   Launch-on-Warning
LPAR  Large Phased-Array Radar
LUA   Launch-Under-Attack
MB    Material Balance equation
MBA   Material Balance Area
MC&A  (Fissile) Material Control and Accounting
Minatom Ministry of Atomic Energy (Russia)
MIRV  Multiple Independently-Targetable Reentry Vehicle
MOD   Ministry of Defense (Russia)
MOX   Mixed-Oxide nuclear fuel
MPC&A (Fissile) Material Protection, Control, and Accounting
MUF   “Material Unaccounted For”
NATO  North Atlantic Treaty Organization
NCA   National Command Authority (Pakistan)
NDA   Non-Destructive Assay
NIS   Newly-Independent States
NMD   National Missile Defense
NNMSS Nuclear Materials Management and Safeguards System (U.S.)
NORAD  North American Aerospace Defense Command (U.S.)
NPT    Nuclear Nonproliferation Treaty
NRB    Nuclear Regulatory Board (Pakistan)
NRC    Nuclear Regulatory Commission (U.S.)
NSC    National Security Council (India)
NUMAC  Nuclear Material Accounting and Control organization (India)
NWS    Nuclear Weapons State
OTH    Over-the-Horizon (radar)
PAEC   Pakistan Atomic Energy Commission
PAL    Permissive Action Link
PAVE PAWS  Precision Acquisition of Vehicle Entry Phased-Array Warning System (U.S.)
PES    Permissive Enable System (U.S.)
PFRB   Prototype Fast Breeder Reactor (India)
PHWR   Pressurized Heavy-Water Reactor (India)
PIDAS  Perimeter Intrusion Detection and Assessment System (U.S.)
PIN    Personal Identification Number
PINSTECH  Pakistan Institute of Nuclear Science and Technology
PLA    People’s Liberation Army (China)
PNIs   Presidential Nuclear Initiatives (U.S. and Russia)
PNRA   Pakistan Nuclear Regulatory Authority
PP     Physical Protection
PRP    Personnel Reliability Program
PSLV   Polar Satellite Launch Vehicle (India)
Q-5    Qian-5 bomber (China)
RVSN   Russian Strategic Rocket Forces
SAC    Strategic Air Command (U.S.)
SALT   Strategic Arms Limitation Treaty (U.S.-Soviet)
SAM    Surface-to-Air Missile
SLBM   Submarine-Launched Ballistic Missile
SLCM   Sea-Launched Cruise Missile
SLV    Satellite Launch Vehicle
SNM    Special Nuclear Materials
SRAM   Short-Range Attack Missile
SRBM   Short-Range Ballistic Missile
SSBN   Ballistic Missile Submarine
START I and II  Strategic Arms Reduction Treaty I and II (U.S.-Russia)
TEL    Transporter Erector Launcher
USSTRATCOM  United States Strategic Command
VMD    Video Motion Detector
WMD    Weapons of Mass Destruction
WPC&A  Warhead Protection, Control, and Accounting
WTO    World Trade Organization
Chapter 1: The Optimism-Pessimism Debate and the Research Agenda of this Dissertation

One of the highest security priorities of the United States and the international community in the post-Cold War era has been to prevent the horizontal proliferation\(^1\) of nuclear weapons to aspiring states and terrorist groups. The underlying assumption for these efforts is that the proliferation of these weapons of mass destruction is against U.S. and international interests. For example, after reviewing its defense policy, the Clinton administration “concluded that the spread of weapons of mass destruction posed the most direct threat to U.S. post-Cold War security interests.”\(^2\) In its efforts to stop the proliferation of nuclear weapons, the United States has encouraged states to sign the 1968 Non-proliferation Treaty (NPT), by which states not already possessing nuclear weapons pledge not to develop nuclear weapons, and current, officially recognized, nuclear weapons states (NWSs)\(^3\) pledge not to assist non-nuclear weapon states (NNWSs) in the development of nuclear weapons. The United States and the international community have also tried to ensure state compliance with NPT requirements, and have attempted to block the development of nuclear weapons programs in so-called “rogue states,” or “states of concern,” such as Iran, Iraq, and North Korea, who seem determined to develop nuclear weapons programs in spite of these efforts.

But this position against the spread of nuclear weapons presupposes an answer to a more fundamental question, one which is hotly contested among international relations (IR) scholars: What are the likely hazards associated with nuclear weapons proliferation? The answer to this question is by no means clear, and the current IR literature differs widely on it. IR scholars are divided into roughly two schools: proliferation “optimists,” who believe that proliferation can be beneficial and that its associated hazards are not that significant (or are at least surmountable),

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\(^1\) Horizontal proliferation refers to the spread of nuclear weapons to new states and non-state groups who did not possess them before. It should be distinguished from vertical proliferation, which refers to these groups increasing the size of already-existing arsenals. Unless otherwise noted, however, I will follow the general trend of international relations scholarship and use the general term “proliferation” to refer only to the horizontal proliferation of nuclear weapons.


\(^3\) For convenience, I use the term Nuclear Weapon State (NWS) to refer to any country that possesses nuclear weapons (including India, Pakistan, and Israel), not just the five officially recognized nuclear weapons states (United States, Russia, China, Great Britain, and France).
and proliferation "pessimists," who believe the opposite.\(^4\) The specific "hazards" in question are largely not contested. As far as I know, for example, no one contests the sheer destructive force of nuclear weapons.\(^5\) What the optimists and pessimists disagree about is the likelihood of the use of these weapons, and the scale of their use, either intentionally or accidentally, by either a state or non-state group.

This debate between the optimists and pessimists is clearly relevant on a policy level, but it also takes place on a theoretical level, for it centers upon a theoretical disagreement about "how best to explain and predict the behavior of states."\(^6\) In order to support their positions, both the optimists and pessimists offer competing theories to explain state action. As we will see, optimists offer "rational deterrence theory," which contends that states behave as unitary, rational actors, while pessimists offer "organization" theory, which contends that organizational, bureaucratic, and other factors limit the rationality of state action.\(^7\) Because this debate is fundamentally a theoretical one, it should be of interest not only to policy-makers and arms control specialists, but also to mainstream IR scholars.

This dissertation helps test the basic theories and assumptions of the optimists and pessimists by examining whether current NWSs have adequate controls over their nuclear arsenals and fissile material stockpiles (highly enriched uranium [HEU] and plutonium), and by exploring possible reasons why states do or do not implement these controls. This project consists of a series of systematic analyses of the nuclear programs in the United States, Russia, China, India, and Pakistan. These case studies identify the strengths and weaknesses of various systems of nuclear controls in use by current NWSs, and assess what types of nuclear controls the countries with emerging nuclear arsenals are likely to employ. Each case study examines two major topics. The first is "command, control, communication, and intelligence" (C^3I), that is, the technologies and procedures designed to prevent accidental, unauthorized, or inadvertent

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\(^4\) As David Karl points out, it is difficult to divide a large debate into two simple categories. The optimists themselves can be divided into two groups: optimists such as John Mearsheimer and Bruce Bueno de Mesquita argue in favor of "carefully managed" or "selective" proliferation, while optimists such as Kenneth Waltz, Jordan Seng, and David Karl are fairly optimistic about proliferation to any and all states. See Karl, "Proliferation Pessimism and Emerging Nuclear Powers," pp. 88-89, n. 6.


\(^6\) Ibid., p. 116.

use. The second major topic is fissile material protection, control, and accounting (MPC&A), which helps prevent proliferating countries and terrorist groups from obtaining fissile materials (for use in nuclear and radiological devices) and helps prevent the sabotage of nuclear facilities.

In Part I of this chapter, I discuss in greater detail the theoretical disagreement between the optimists and pessimists and show how the present study fits into their debate. In Part II, I present the specific research agenda for this dissertation.

**Part I: The Nuclear Proliferation Debate**

There have been two rounds to the proliferation debate. The first round focused primarily on the relative stability between the superpowers during the Cold War and on the role that nuclear deterrence might have had in maintaining this stability. The optimist and pessimist positions in the first round are best articulated by the writings of Kenneth Waltz and Scott Sagan, although a number of other scholars also contributed to the debate. As the optimist and pessimist positions developed and changed in the course of the debate, the positions taken by optimists and pessimists in the first round have become known by the (rather cumbersome) labels: "paleooptimism" and "neo-pessimism."

The second round of the debate has been taken up primarily by the "neo-optimists" David Karl and Jordan Seng and the "neo-pessimist" Peter Feaver, and has focused almost exclusively on the risks associated with emerging NWSs proliferating rates. The next sections describe the basic arguments brought forward in each of the two rounds of the debate.

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8 The specific definitions for accidental, unauthorized, and inadvertent use are discussed below. See pp. 10–11.
9 Radiological devices are discussed on p. 18 below.
11 I follow the terminology introduced in Peter Feaver, "Neo-optimists and Nuclear Proliferation's Enduring Problems," *Security Studies*, vol. 6, no. 4 (Summer 1997), p. 95.
The First Round: "Paleooptimists" vs. "Neopessimists"

It is no accident that the scholar who has presented the most systematic and powerful arguments in favor of the paleooptimistic position is Kenneth Waltz, since the paleooptimists' arguments are largely grounded on the same assumptions as neorealism, the IR theory for which Waltz is a leading spokesman. In his 1981 Adelphi Paper, *The Spread of Nuclear Weapons: More May Be Better*, Waltz responds to traditional pessimist arguments, made primarily by U.S. policy-makers, that recommended preventing the spread of nuclear weapons to developing countries because irrational elites in those countries would be more likely to engage in nuclear wars. In response to these arguments, Waltz maintains that rational deterrence theory has demonstrated that nuclear weapons can actually increase stability among states. Waltz begins his analysis by arguing that because states exist in an anarchic self-help system, they must rely solely upon themselves to maintain their security. Given this system, the best way that a state can keep an aggressor from attacking is through credible deterrence.13 Waltz defines deterrence in the following way:

“To deter” literally means to stop people from doing something by frightening them. In contrast to dissuasion by defense, dissuasion by deterrence operates by frightening a state out of attacking, not because of the difficulty of launching an attack and carrying it home, but because the expected reaction of the opponent may result in one’s own severe punishment.

Nuclear weapons, optimists argue, provide one of the very best forms of deterrence, since the potential costs of attacking a nuclear weapon state are extremely high. Optimists therefore conclude that the spread of nuclear weapons can be beneficial because it decreases the likelihood of war. As Bruce Bueno de Mesquita and William Riker conclude, “Once half the nations in the system have nuclear weapons, the number of possible nuclear attacks diminishes, going to zero

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13 Waltz, “More May Be Better,” p. 3.
14 Ibid., p. 3.
15 This is a central element in all of the optimists' arguments, not just Waltz's. See, for example, Mearsheimer, “Back to the Future,” pp. 8, 11, and 37.
when all countries have sufficient capabilities to deter their relevant adversaries.\textsuperscript{16} In fact, Waltz argues that even the possibility of a nuclear retaliation would be sufficient to deter any attack (both conventional and nuclear) by an otherwise aggressive state. As Waltz asks rhetorically, "why fight if you can't win much and stand to lose everything?"\textsuperscript{17}

The implicit assumption of the optimists is that states are unitary, rational actors, which consistently act so as to maximize their self-interest.\textsuperscript{18} As Waltz argues, "We do not have to wonder whether they [NWSs] will take good care of their weapons. They have every incentive to do so."\textsuperscript{19} The premise of this argument is that states always recognize what is in their interest when the stakes are as high as nuclear war, and that their actions will reflect these interests.

This is precisely the premise that a new wave of pessimist literature challenged in the late 1980s and early 1990s. These "new pessimists," or "neopessimists"\textsuperscript{20} argue that states often do not act as unitary, rational actors. Rather, neopessimists argue, states encounter organizational and bureaucratic obstacles that prevent them from acting in coherent, rational ways. In response to the optimists, Scott Sagan presents an "organization theory," which "challenges the central assumption that states are unitary actors behaving in a self-interested way."\textsuperscript{21} Organization theory incorporates two general themes, both of which dispute the premise that states are unitary, rational actors. The first theme contends that

large organizations function within a severely "bounded" form of rationality: they have inherent limits on calculation and coordination and use simplifying mechanisms to understand and respond to uncertainty in the external environment. Organizations, by necessity, develop routines to coordinate among different units: standard operating procedures and organizational rules, not individually reasoned decisions, therefore govern much behavior.\textsuperscript{22}

\textsuperscript{16} Bueno de Mesquita and Riker, "Selective Nuclear Proliferation," p. 287. They do argue, however, that the likelihood of preemptive strikes is higher when a small number of states possess nuclear weapons. During the time when the number of states possessing nuclear weapons is less than half the system, the likelihood of nuclear attack actually increases as proliferation increases. The likelihood only decreases after half of the countries in the world possess nuclear weapons (ibid., p. 288).
\textsuperscript{17} Waltz, "More May Be Better," p. 5.
\textsuperscript{18} For a brief, but important discussion of what "rational" might mean in "rational deterrence theory," see Blight and Welch, "Risking the Destruction of Nations," p. 815, n. 12.
\textsuperscript{19} Waltz, "More May Be Better," p. 21.
\textsuperscript{20} For the introduction of these terms, see Karl, "Proliferation Pessimism and Emerging Nuclear Powers," pp. 93–95; and Feaver, "Neopessimists and the Enduring Problem of Nuclear Proliferation," pp. 93–99.
\textsuperscript{22} Sagan, "The Perils of Proliferation," p. 72.
Along similar lines, Sagan also contends that large organizations are characterized by ‘satisficing’: “rather than searching for the policy that maximizes their utility, they often accept the first option that is minimally satisfying.”23 Much of the work done by pessimists can be grouped into this general argument. For example, neopessimists often point to many examples of organizational problems that could arise, and have arisen, from standard operating procedures during times of crisis.24 Other pessimist criticisms that fit into this general category are arguments that states will not always create arsenals that can survive a nuclear strike, which gives aggressors the incentive to strike first,25 and that both large organizations and poor countries necessarily encounter severe obstacles in the command and control of their arsenals.26

The second general theme in organization theory is that “complex organizations commonly have multiple conflicting goals and the process by which objectives are chosen and pursued is intensely political....Organizations are not simply tools in the hands of higher-level authorities, but are groups of self-interested and competitive sub-units and actors.”27 There has been a great deal of pessimist emphasis on this point as well. For example, they argue that certain groups such as the military might be more likely to use nuclear weapons than civilians,28 and that parochial interests within certain bureaucracies can preclude systematic implementation of controls and safety measures for their weapons systems.29

23 Ibid., p. 72.
26 Feaver, “Correspondence: Proliferation Pessimism and Emerging Nuclear Powers,” p. 189.
29 Sagan, “The Perils of Proliferation,” p. 74; Sagan, “Sagan Responds to Waltz,” p. 128. The problems arising from bureaucratic parochialism will be very important in this study. For example, there is significant evidence that parochialism caused Russia’s Ministry of Atomic Energy (Minatom) to refuse to admit that there was a problem with Russia’s nuclear controls. According to Allison et. al: “To date, key players in Russia—particularly including Minatom and its head, Viktor Mikhailov—have been unenthusiastic about and even often unwilling to engage in cooperation with the United States to improve nuclear security. In fact, they have been reluctant even to concede that there is a problem (since such acknowledgment amounts to self-condemnation).” Graham Allison, Owen Cote, Richard Falkenrath, and Steven Miller, Avoiding Nuclear Anarchy (Cambridge: The MIT Press, 1996), p. 75; see also pp. 124–126.
The emphasis of the proliferation debate changed with the publication of two articles, one by David Karl and the other by Jordan Seng. These articles formulated what became known as the neooptimist position. Seng and Karl argue that the experiences of emerging or minor nuclear weapons states will be fundamentally different from the experiences of the superpowers during the Cold War. They both argue that greater economic and technical constraints in emerging nuclear states will force them to rely on much smaller nuclear arsenals than those possessed by the superpowers. The neooptimists argue that emerging NWSs will avoid many of the command and control problems predicted by the neopessimists, since most of the early neopessimist arguments focused on the organizational difficulties that arise from large nuclear arsenals. In response, Peter Feaver has argued extensively that these very economic and technical constraints will weaken command and control in emerging NWSs. Thus, Feaver argues, one has continuing reason to be pessimistic about the prospects of spread of nuclear weapons.

The debate between the neooptimists and neopessimists has focused on several key issues, including survivability, command and control, political stability, and the role of opacity. I discuss each of these issues in turn, below.

Survivability

Because the second round of the proliferation debate has focused primarily on small arsenals in emerging NWSs, it is a serious question whether these states will be able to create forces that are capable of surviving a nuclear first strike. If they do not, then their adversaries would have strong incentives to engage in preemptive nuclear strikes to destroy the vulnerable arsenals. On this issue, the neopessimists argue that the states will be unable to create survivable forces, due to financial constraints, technical limitations, and organizational problems. Neooptimists argue in response that the emerging nuclear states will be able to create survivable forces by simply concealing their forces. Since "one cannot destroy what one cannot see," if
emerging NWSs use effective (and relatively inexpensive) concealment strategies, they will ensure that their forces will survive a first strike.

Command and Control

Both Karl and Seng argue that smaller arsenals will allow emerging NWSs to have relatively strong command and control over their nuclear weapons. Because they will have fewer nuclear weapons to control, emerging NWSs will be able to protect their weapons much more effectively, even without the sophisticated command-and-control systems employed by the United States and the Soviet Union.33 Feaver responds to such arguments that use-control devices are still necessary for preventing terrorist seizure of nuclear weapons and unauthorized launches. These problems will remain, Feaver argues, even if there are fewer weapons to control.34 In addition, neopessimists argue, even though financial constraints will make arsenals smaller, the arsenals will tend to be “untested, unproven, and probably unsafe.”35 And finally, neopessimists argue, even though emerging NWSs will initially have smaller arsenals, there is no guarantee that they will remain satisfied with the “minimal deterrence” that small arsenals provide.36 If the emerging NWSs decide to build up their arsenals, they will then encounter the organizational problems that pessimists have associated with large arsenals.37

Political Instability

Because many of the emerging nuclear states will tend to be less stable than the established NWSs have been, several pessimists have argued that arsenals in emerging NWSs will be particularly susceptible to accidental and unauthorized use, especially during political and social upheavals. This is particularly the case because emerging NWSs will tend to have fewer use-control and safety devices, such as those employed by the superpowers.38 In response to these arguments, Seng has argued that because emerging NWSs have fewer nuclear weapons to care for, they will be able to avoid many of the risks of accidental and unauthorized use, even during political crises. In fact, Seng argues that domestic political instability will cause

34 Feaver, “Neooptimists and Nuclear Proliferation’s Enduring Problems,” p. 103.
36 Ibid., p. 105.
37 Ibid., p. 107.
emerging NWSs to employ stronger security over their nuclear forces than they otherwise would have, because they will take countermeasures to insulate their nuclear organizations from political fluctuations and ensure the loyalty of the protective forces for their nuclear weapons. Feaver has argued in response to Seng that political instability will tend to undermine the reliability of military personnel (the primary means by which emerging states will control their nuclear forces, since they will have fewer technological controls), and will therefore greatly weaken command and control.

**Opacity**

As Avner Cohen and Benjamin Frankel argue, proliferating states can be divided into two categories, visible and opaque. The countries that have proliferated visibly are the five officially recognized nuclear powers (United States, Russia, China, France, and Great Britain), and more recently India and Pakistan. Opaque proliferators are the states that are developing, or already have developed, nuclear weapons capabilities, after the creation of the international non-proliferation regime, embodied above all in the NPT and the International Atomic Energy Agency (IAEA). According to Cohen and Frankel, opaque proliferators are characterized by the following features: no nuclear tests, denial of possession of nuclear weapons, no direct nuclear threats, no nuclear military doctrine, no nuclear military deployment, no open debate about their nuclear weapons programs, and organizational insulation. Opaque proliferators include Israel, India and Pakistan (prior to their nuclear weapons tests in 1998), and any other states with secret nuclear weapons programs (such as Iraq and North Korea had and possibly still have).

Optimists and pessimists take opposing views on the safety measures that opaque proliferators will take to secure their weapons arsenals. Optimists such as Karl argue that arsenals in opaque states are actually safer than in visible ones, because opaque states often do

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40 Feaver, "Neooptimists and Nuclear Proliferation’s Enduring Problems," pp. 112–114, 118.
41 Avner Cohen and Benjamin Frankel, "Opaque Nuclear Proliferation," _Journal of Strategic Studies_, vol. 13, no. 3 (September 1990), p. 16.
42 Ibid., pp. 21–22.
43 Although India conducted a nuclear test in 1974, Cohen and Frankel argue that enough similarities existed in its behavior (prior to the 1998 test) to identify it as resembling the opaque "ideal-type" (ibid., p. 23). Indeed, at the time, India declared the 1974 test to be a "peaceful nuclear experiment" and not part of a weapons program.
not assemble their arsenals. Pessimists such as Feaver, however, respond by arguing that opacity decreases both organizational oversight and “nuclear learning” about possible flaws in weapons designs and safety measures.

Why Are C'I and MPC&A Important To This Debate?

Now that we have examined the arguments made by the optimists and pessimists, we need to consider how this study fits into their debate. In this section, I demonstrate how both C'I and MPC&A are, or should be, central issues in the proliferation debate.

C'I and Risks of Accidental, Unauthorized, and Inadvertent use

As Peter Stein and Peter Feaver explain, command and control over nuclear weapons can be characterized as an “always/never” problem: “Nuclear weapons must always detonate when those authorized direct and never detonate when those authorized do not.” The “always” side of command and control is achieved by making reliable weapons and strong communication links. The “never” side is achieved by overcoming two separate threats to the system: accidental use and unauthorized use. The use of a nuclear weapon would be considered accidental if “everyone is surprised” by its use. Unauthorized use, on the other hand, “refers to the deliberate use by people who have access to the weapon, but who lack authority legitimately to order its use.” For example, if a state lacked adequate controls over its nuclear weapons, a crazed soldier or fanatic general could independently decide to use the state’s nuclear weapons, even though its central authorities had not ordered their use. Or, alternatively, a terrorist group could steal a nuclear weapon and use the weapon on its own.

Both accidental and unauthorized use must be distinguished from an “inadvertent” use of a nuclear weapon, where the use is intentional and ordered by the people who have legitimate authority to order its use, but the order is based on misinformation. According to the Rumsfeld Commission to Assess the Ballistic Missile Threat, inadvertent use is defined as “one resulting from a mistaken assessment of sensor data, including from ballistic missile early warning

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45 Feaver, “Correspondence: Proliferation Pessimism and Emerging Nuclear Powers,” p. 191.
47 Stein and Feaver, Assuring Control of Nuclear Weapons, p. 8.
systems, or a misinterpretation of the strategic situation or some combination of the two, especially in times of crisis generated either by domestic or international events.\textsuperscript{49} For example, if a state's early-warning system failed, it could launch a nuclear strike against an enemy because it mistakenly thought that the enemy had attacked first.

The various technologies and procedures intended to prevent accidental, unauthorized, and inadvertent use are generally categorized as C\textsuperscript{3}I. It is fairly easy to see why adequate C\textsuperscript{3}I is necessary for stable deterrence. If a state were accidentally to launch a nuclear weapon against another state, or, for example, a crazed general were to do so, the state runs a high risk of retaliation.\textsuperscript{50} The state would run similar risks of retaliation if it launched its weapons as a result of a false alarm or a similar intelligence failure. Any of these events would obviously undermine the very intention of nuclear deterrence, which is to prevent a nuclear attack. In addition, if a state becomes aware that an enemy's arsenal is not secure against accidental or unauthorized use, deterrence can be less effective. A deterrent threat says "if you attack, you will be severely punished."\textsuperscript{51} But if a given state's arsenal is not secure, it threatens to harm or destroy other states even if the other states are not contemplating an attack. Another state might have a strong incentive to preempt a strike that could otherwise come at any time.\textsuperscript{52}

As we will see, both optimists and pessimists agree that states have a very strong interest to prevent accidental, unauthorized, and inadvertent use, but they disagree over whether or not emerging NWSs will be able to prevent these events from occurring.\textsuperscript{53}

\textit{Accidental Use}

Pessimists argue that nuclear weapons in proliferating states will be susceptible to accidental use because the weapon designs will tend to be relatively crude and the weapons will not have undergone the proper testing to ensure that they are safe.\textsuperscript{54} In addition, they argue, it is

\textsuperscript{50} Waltz, "More May Be Better," p. 21.
\textsuperscript{51} [bid., pp. 3–4.
\textsuperscript{52} For example, Ralph Clough et al. speculate that the United States might consider such a preemptive attack on China for exactly this reason: "concern that Chinese missiles might be launched by accident, or fear that Peking might misread our intentions and launch its missiles first, might tempt some U.S. leaders to consider a preemptive strike in order to limit damage to this nation." See Ralph A. Clough, Doak Barnett, Morton Halperin, and Jerome Kahan, \textit{The United States, China, and Arms Control} (Washington, D.C.: Brookings Institute, 1975), p. 34.
\textsuperscript{53} Waltz, "More May Be Better," p. 20.
less likely that these states will have sufficient resources to implement the procedures and technologies necessary for preventing accidental use. The states will therefore be forced to make compromises—cutting corners in critical technologies, or even simply considering safety issues to be less important than the initial development of nuclear arsenals. Safety and control measures will therefore be marginalized, or even largely ignored, as states focus on other priorities.55

Optimists such as David Karl argue that emerging NWSs can overcome many of these obstacles by storing their nuclear weapons in a disassembled state.56 For example, the risks of accidental use can be greatly reduced if the nuclear components in the weapons are stored away from the nonnuclear ones, or if warheads are stored apart from their delivery vehicles. But pessimists respond to such arguments first, that short flight times for ballistic missiles and concerns about the survivability of nuclear forces will probably cause emerging NWSs to maintain their weapons in an assembled, ready-response mode, just as the United States and Russia do.57 And second, pessimists argue that even if unassembled nuclear weapons are safer during normal, peacetime circumstances, the chances of accidental use could increase dramatically if the state were forced to assemble its weapons rapidly during a crisis.58

Unauthorized Use

Both sides of the debate agree that NWSs must have adequate controls to prevent unauthorized use. As we have seen, optimists are confident that NWSs will implement adequate controls against the unauthorized use of their nuclear weapons because it is so clearly in their interest to do so.59 Seng and Karl, in particular, argue that it will be relatively easy for emerging NWSs to ensure proper security for their weapons because their arsenals will be small and their operational systems simple. And the pessimists argue that limited resources, a lack of use-control technologies, and political instabilities will constrain emerging states' abilities to protect their nuclear arsenals against unauthorized use.

58 Blair, The Logic of Accidental Nuclear War, p. 254; Feaver, "Neooptimism and Nuclear Proliferation's Enduring Problems," pp. 176–177; Feaver, "Correspondence: Proliferation Pessimism and Emerging Nuclear Powers," p. 191
59 Waltz, "More May Be Better," p. 21
Inadvertent Use

Optimists and pessimists also agree NWSs must avoid weapon deployments that could lead to inadvertent launches. These include deployments that require rapid-response or policies that call for launch-on-warning (LOW), which requires a state to fire its nuclear weapons after an attack is detected but before the incoming nuclear weapons have reached their targets. For example, Kenneth Waltz argues that "survival of forces must not require early firing in response to what may be false alarms." Thus, Waltz acknowledges that if NWSs do, in fact, tend to develop rapid-response capabilities and policies of LOW, then the risks of inadvertent use would be quite high, since these doctrines greatly reduce the time that leaders have to decide whether to launch their nuclear weapons. But optimists argue that emerging NWSs will not develop these capabilities and use-doctrines because they will be able to ensure survivability by dispersing and concealing their nuclear weapons. Instead, optimists argue, emerging NWSs will adopt force doctrines that call for "riding out" a first-strike, then engaging in a delayed retaliation.

As a number of pessimists have pointed out, however, a doctrine of ride-out and delayed retaliation increases a state's vulnerability to decapitation (where those authorized to order a retaliation are killed or the communication networks necessary for disseminating a launch command are severely disrupted or destroyed) and to counterforce strikes (where large numbers of the state's nuclear forces are destroyed), both of which significantly reduce the state's retaliatory capability. Pessimists have therefore argued that emerging NWSs will not be satisfied with such doctrines, and will instead develop rapid-response capabilities and even adopt policies that allow for LOW.

60 Ibid., p. 20. See also Seng, "Less is More," p. 78.
61 Although the United States and the Soviet Union developed such capabilities and use-doctrines, optimists dismiss these actions as reflecting "decades of fuzzy thinking." See Kenneth Waltz, "Nuclear Myths and Political Realities," American Political Science Review, vol. 84, no. 3 (September 1990), p. 731.
**Fissile Material Protection, Control, and Accounting (MPC&A)**

As previously stated, MPC&A is critical both for stopping the proliferation of nuclear weapons to aspiring nuclear states and for preventing nuclear terrorism. I will discuss each in turn.

*MPC&A Helps Prevent the Spread of Nuclear Weapons to Aspiring Nuclear Weapons States*

If states have inadequate MPC&A, then aspiring nuclear states might be able to obtain smuggled or stolen fissile materials, greatly reducing the time it would take to produce nuclear weapons. To a certain degree, the specific dangers of this depend on the results of my study of the C3I systems in NWSs. If it turns out that NWSs do not take sufficient care to protect their arsenals from accidental, unauthorized, or inadvertent use, then the necessity for MPC&A will be clear—it would be needed precisely because proliferation is not desirable. But there are additional reasons why both optimists and pessimists should view MPC&A as necessary.

Most optimists in fact agree that the spread of nuclear weapons to aspiring states must be both gradual and carefully managed for it to have any stabilizing effects. Mearsheimer, for example, thinks that some proliferation of nuclear weapons can be beneficial, but that the effects of proliferation “depend upon how it is managed. Mismanaged proliferation could produce disaster, while well-managed proliferation could produce an order nearly as stable as the [Cold War] order.” Proponents of such qualified optimist positions give various reasons for their support of only “well-managed” proliferation, citing the problems associated with proliferation in poor states, the inherent instability in the transition to nuclear weapons, and the increased chances of preemptive strikes. Even Waltz argues that the “gradual spread of nuclear weapons is better than either no spread or rapid spread.” But unless states have tight and reliable controls over their fissile materials, then proliferating states might be able to obtain stolen materials, greatly reducing the technical obstacles and decreasing the time required for producing nuclear

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52 Mearsheimer, “Back to the Future,” p. 37. Mearsheimer argues that the bi-polar nuclear order of the Cold War would be more stable than a multi-polar nuclear order because there would be fewer fingers on triggers and fewer chances of confusion or misperception. Thus, while Mearsheimer recognizes some problems that could arise from proliferation, he does not think that they outweigh the advantages of increased deterrence that would arise from carefully-managed proliferation. For a similar argument in favor of only carefully-managed proliferation, see Bueno de Mesquita and Riker, “Selective Nuclear Proliferation,” p. 303.

Thus, if NWSs do not have MPC&A systems to prevent fissile material thefts, the subsequent spread of nuclear weapons could be rapid, and therefore extremely destabilizing.

Moreover, a rapid development of nuclear arsenals could also increase the risks of accidental and unauthorized use, because the emerging NWSs would not necessarily have had time to establish the infrastructures and controls necessary for safe maintenance of their nuclear arsenals. Indeed, Waltz is confident that emerging NWSs will "have time to learn how to care for" their arsenals, because they "can build sizable forces only over long periods of time." But if newly proliferating states have access to sufficient quantities of smuggled or stolen fissile materials, the time it would take to produce a sizable force could be greatly reduced. If NWSs have inadequate MPC&A, then Waltz's argument is much weaker: emerging NWSs would not necessarily have the time to learn about how to ensure the safe care of their nuclear weapons. Thus, the optimists' own arguments imply that adequate MPC&A must be implemented by established and aspiring nuclear weapons states.

**MPC&A Helps Prevent Nuclear Terrorism**

While the issue of nuclear terrorism has been discussed extensively in government circles, it has only been marginally treated in the proliferation debate. As some optimists have noted, however, the chance that a terrorist group could seize nuclear weapons could increase if other countries developed nuclear weapons because the number of possible access points would increase. In fact, this is one of the main reasons why John Mearsheimer thinks that proliferation should not be encouraged in poor countries, which might not be able to maintain rigorous controls over their nuclear weapons.

The possibility of a terrorist group obtaining nuclear weapons should be especially troubling to optimists precisely because their arguments are based on deterrence theory. Deterrence can only work if one has an easily identifiable, immobile target, such as a state, against which one can retaliate. Since one cannot necessarily retaliate against terrorist groups in

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64 It is widely accepted that the most difficult part of developing a nuclear weapon is producing fissile materials. If a proliferating state were able to obtain large amounts of stolen fissile materials, its task would be much easier. Indeed, Iran, Iraq, Libya, and North Korea, among others, have all been reported to be actively seeking to acquire stolen fissile materials for nuclear weapons. See Matthew Bunn, *The Next Wave: Urgently Needed New Steps to Control Warheads and Fissile Materials* (Carnegie Endowment for International Peace and Harvard University, 2000), pp. 14–15.


this way, nuclear deterrence may be largely ineffective against them. Because terrorists may not easily be deterred, it is in the interest of all states to have excellent MPC&A systems in place to ensure that fissile materials cannot be stolen from their nuclear facilities.

The risks of nuclear terrorism have not been taken very seriously by many optimists, in part due to Waltz’s arguments that it is unlikely that terrorists would even want to develop nuclear capabilities. Waltz’s first argument is that the decision to “go nuclear” would require too great an expansion of the terrorist group, which runs counter to the secrecy that terrorists require: “Terrorists work in small groups. Secrecy is safety, yet to obtain and maintain nuclear weapons would require enlarging the terrorist band through multiplication of suppliers, transporters, technicians, and guardians. Inspiring devotion, instilling discipline, and ensuring secrecy become harder tasks to accomplish as numbers grow.” In addition, Waltz argues that nuclear weapons do not fit into most terrorist agendas, which are met through “patient pressure and constant harassment. They cannot hope to do so by issuing unsustainable threats to wreck [sic] great destruction, threats they would not want to execute anyway.”

While Waltz’s arguments about terrorist goals might have been convincing in the past, there is significant evidence that terrorist goals are changing. Many analysts of terrorism have identified a trend among terrorists toward brutal, indiscriminate killing. These analysts conclude that interest may be increasing among terrorists for acquiring weapons of mass

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69 Some states might consider it to be in their interests to provide certain terrorist groups with nuclear weapons. See Leonard D. Spector, “Clandestine Nuclear Trade and the Threat of Nuclear Terrorism,” in Paul Leventhal and Yonah Alexander, eds., Preventing Nuclear Terrorism (Lexington: Lexington Books, 1987), p. 78. But it is in the interest of even these states to implement adequate MPC&A systems. After all, they would still want to maintain a strict control over which terrorist groups developed nuclear weapons. If there were significant nuclear leakage from the state, then this control would be lost, and terrorist groups directed against the state itself might also develop nuclear weapons.
71 Ibid., p. 96.
72 Ibid., p. 96. This argument is essentially the same as the one made in Brian Jenkins, “International Terrorism: A New Mode of Conflict,” in David Carleton and Carlo Schafer, eds., International Terrorism and World Security (London: Croom Helm, 1975), p. 15.
destruction (WMD), including nuclear weapons. The main reason for this change in terrorist goals appears to be a rise in religious, or "holy," terror, which tends to view such violence "not only as morally justified, but as a necessary expedient for the attainment of their goals."

The most prominent example of such a trend is the terrorism sponsored by Osama bin Laden. After the bombings of two U.S. embassies in 1998, believed to have been conducted by bin Laden's organization al Qaida, the United States formally accused bin Laden of having tried to acquire fissile materials for nuclear weapons in 1993. And bin Laden is not alone in his attempts to acquire weapons of mass destruction for terrorist purposes. According to George J. Tenet, U.S. Director of Central Intelligence, "Bin Laden's organization is just one of about a dozen terrorist groups that have expressed an interest in or have sought chemical, biological, radiological, and nuclear agents."

Fortunately, building a nuclear weapon from fissile materials is currently beyond the capabilities of most, if not all, terrorist groups. While many scholars have argued that it is relatively easy to make a fission bomb once one has fissile materials, this is probably not the case. One need only look at the difficulties that Iraq had in producing a nuclear weapon—even after devoting extensive money and manpower to the task—to see that producing a nuclear weapon is not as easy as many claim. For this reason, most terrorists interested in WMD would probably attempt to develop chemical or biological weapons rather than nuclear ones. Nevertheless, it would clearly be foolish to make the job easier for any terrorists who do wish to develop nuclear weapons by allowing them access to fissile materials. Because we cannot rule out the possibility that terrorist groups might resort to nuclear terrorism, NWSs have an additional incentive to implement adequate measures to prevent thefts of fissile materials.

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74 Hoffman, "Terrorism and WMD," p. 48. See also Hoffman, "‘Holy Terror,’" p. 5.
76 George J. Tenet, Statement of the Director of Central Intelligence, prepared delivery before the Senate Armed Services Committee Hearing on Current and Projected National Security Threats, February 2, 1999, p. 4.
78 For example, see Allison, et al., Avoiding Nuclear Anarchy, p. 54; Morten Bremer Maerli, "Relearning the ABCs: Terrorists and 'Weapons of Mass Destruction',' Nonproliferation Review, vol. 7, no. 2 (Summer 2000), pp. 108–119.
In addition, there are a number of types of nuclear terrorism other than making or stealing a nuclear weapon. The following terrorist acts should all be classified as nuclear terrorism:

1. Making or stealing a nuclear or radiological weapon for detonation.
2. Making or stealing a nuclear or radiological weapon for blackmail.
4. Attacking a nuclear weapons site to spread alarm.
5. Attacking a nuclear plant to spread alarm.
6. Holding a nuclear plant for blackmail.
7. Stealing or sabotaging “things nuclear” for demonstration purposes.
8. Attacking a transporter of nuclear weapons or materials.\footnote{This list is loosely based on the list of the types of nuclear terrorism in Konrad Kellen, “The Potential for Nuclear Terrorism: A Discussion,” in Paul Leventhal and Yonah Alexander, eds., Preventing Nuclear Terrorism (Lexington: Lexington Books, 1987), p. 106. Kellen does not identify radiological weapons as nuclear terrorism, though they have begun to be identified as nuclear terrorism in recent years.}

Although most of the terrorist activities listed above are relatively clear, a few require further explanation. A radiological device is a bomb where radioactive materials are attached to conventional explosives. The explosion of a radiological device could spread radioactive contamination over a relatively large area. Not only could such a detonation cause serious environmental damage and render large areas unusable because of the contamination, it would cause public hysteria.\footnote{Hoffman, “Terrorism and WMD,” p. 50.} In addition, if plutonium were used in a well-designed radiological device, the resulting explosion could disperse a cloud of plutonium aerosol, which could be deadly if inhaled.\footnote{“Crude Nuclear Weapons: Proliferation and the Terrorist Threat,” International Physicians for the Prevention of Nuclear War, Global Health Watch Report, No. 1, p. 34.}

An effective sabotage of a nuclear power or production reactor could create Chernobyl-like effects, dispersing radiation across large areas.\footnote{Bukharin, “Problems of Nuclear Terrorism,” p. 9.} A knowledgeable attacker could damage the reactor cooling system, causing a melting of the reactor core and a steam explosion. The result would be the destruction of the reactor and a release of radioactive materials.\footnote{Ibid., p. 9.}

By implementing rigorous MPC&A technologies and procedures at their nuclear facilities, a NWS will help prevent all of the above types of nuclear terrorism. An effective MPC&A system would greatly reduce the likelihood of successful thefts of materials by workers at a nuclear facility, making it much more difficult for terrorists to obtain fissile materials for use in nuclear or radiological weapons. And insofar as the MPC&A system includes an effective physical protection system, it would deter or defeat direct terrorist attacks on nuclear facilities,
thereby preventing overt thefts of nuclear materials, as well as the capture or sabotage of nuclear facilities.

Part II: Research Agenda

The debate between the optimists and the pessimists focuses largely on whether or not states will implement adequate nuclear controls. Both sides should, and to a certain degree do, agree that it is in states' interests to ensure that they have adequate C3I systems for their nuclear arsenals and adequate MPC&A for their fissile materials. The main point of disagreement between optimists and pessimists is over whether states actually will have such rigorous nuclear controls. A major difficulty with the debate, however, is that it is largely based on a competing set of deductions, derived from different theoretical explanations about how states act. While almost every scholar who has contributed to this debate has called for more empirical research to assess whose claims and predictions are correct,85 with a few exceptions, the debate has nevertheless remained primarily on the theoretical level.86 The specific value added by this dissertation, therefore, is to determine which position has the more realistic understanding of the incentives, capacities, constraints, trade-offs, and subsequent risks that can arise from various nuclear systems and controls. Because this study examines cases that involve countries that vary widely on relevant dimensions, such as wealth, technical capacity, regime type, and political stability, this study will be able to assess what factors affect the ability and willingness of different states to employ various systems of nuclear controls.

86 These exceptions include Blair, The Logic of Accidental Nuclear War; Bruce Blair, Global Zero Alert (Washington D.C.: Brookings Institute, 1995); Sagan, The Limits to Safety; and Peter Feaver, Guarding the Guardians: Civilian Control of Nuclear Weapons in the United States (Ithaca: Cornell University Press, 1992).
Assessing C^I^

Systems and Risks of Accidental, Unauthorized, and
Inadvertent Use

Accidental use

There are two types of accidental use: accidental detonation and accidental launch. An accidental detonation would result from some mishap, such as a plane crash or fire, which causes the warhead to explode, scattering radioactive material or even causing a significant nuclear yield. An accidental launch could result from a technical defect (such as faulty wiring) or unsafe procedures that caused the premature firing of a nuclear-armed missile or release of a nuclear gravity bomb from an aircraft. 87

Accidental Detonation

There are several possible ways for a state to avoid accidental detonations of its nuclear weapons. The first, and possibly the easiest, way would be for a state to store the nuclear components of the weapons separate from high explosive non-nuclear components during storage and transportation. As we have seen, Karl argues that this is the technique that emerging NWSs will probably use. This approach would reduce many, but not necessarily all risks of accidental detonation. As pessimists have pointed out, since the weapons would have to be assembled rapidly prior to use, the state could bypass safety procedures in its haste, increasing risks of accidents. The NWSs would therefore need to train its soldiers to assemble weapons rapidly and safely to help avoid some of these risks.

If, on the other hand, a given NWS decides to store its weapons pre-assembled, however, there are a number of technological means to help avoid risks of accidental detonation. For example, warheads can be designed to allow for “One-point safety,” in which the detonation of the weapon’s high explosive at any single point has a very small probability of producing a significant nuclear yield. 88 In addition, the nuclear weapons could be designed to include

87 The risks of accidental launches are real. For example, in 1998, faulty wiring caused an accidental launch of a South Korean Nike-Hercules surface-to-air missile. The missile exploded 300 meters above the ground, injuring nine people and causing extensive damage to cars and residential homes. For reports on this incident, see Seoul Yonhap, December 4, 1998, in dreas12041998000398 (December 4, 1998) and The Korea Times, December 7, 1998 in dreas12071998001786 (December 7, 1998).

88 U.S. standards for one-point safety require that if the high explosive is detonated at any single point, the probability of producing a nuclear yield exceeding four pounds TNT equivalent is less than one in a million. See Donald R. Cotter, “Peacetime Operations: Safety and Security,” in Ashton B. Carter, John D. Steinbruner, Charles A. Zraket, eds., Managing Nuclear Operations (Washington, D.C.: Brookings Institution, 1987), p. 43. Not all one-
Environmental Sensing Devices (ESDs), which only allow a weapon to detonate if certain environmental conditions are met, such as certain accelerations, changes in barometric pressures, etc. ESDs would keep a missile from exploding if it accidentally fell off a truck or if a plane carrying nuclear weapons crashed. The nuclear weapons could also be designed to include Insensitive High Explosive (IHE) to help avoid accidental detonations of the conventional explosive. Depending on the design of the warhead, an accidental detonation of the high explosive could either cause a significant nuclear yield or cause the plutonium to disperse in a deadly aerosol.\textsuperscript{89} Finally, the nuclear weapon could be designed to include Fire Resistant Pits (FRP). In an FRP, the plutonium is encased in a metal shell with a high melting point, which is designed to withstand exposure to fires.\textsuperscript{90}

\textbf{Accidental Launch}

Again, there are a number of ways to help ensure that accidental launches do not occur. One "low-tech," way to help prevent accidental launches would be to maintain the weapons systems at low states of alert during normal, peacetime circumstances. For example, a state could keep its warheads unmated to the delivery vehicles.\textsuperscript{91} If nuclear warheads are not mated to missiles, and gravity bombs are not loaded onto airplanes during peacetime, the risk of accidental launch would be greatly reduced. Again, however, the risks could increase significantly if warheads were mated and the missiles were prepared for launch during crisis situations.

If the warheads are mated to the delivery systems, then the state must employ other means of preventing accidental launches. For example, a state could avoid keeping its missiles continuously targeted against its enemies or have safety devices such as multiple launch codes to prevent a weapon from being launched by pushing the wrong button. Finally, if an accidental launch were to occur, a state could have integrated into the weapon means of de-activating warheads or aborting the launch.

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\textsuperscript{90} Ibid., p. 49.

\textsuperscript{91} Although it sounds similar, this precaution is different from keeping the warheads themselves disassembled. It is possible to store assembled warheads that are not mated to delivery vehicles.
In order to assess the risk of accidental use, this study will therefore examine the following issues:

- Do NWSs appear satisfied with unassembled weapons, or do they tend to develop assembled weapons, stored in a ready-response mode?
- Are missiles continuously targeted against enemies?
- To what extent do NWSs have integrated safety devices and designs to reduce the risks of accidental detonations and accidental launches?
- Are there means of ensuring that bombers cannot accidentally drop bombs, such as independent locks on their bay doors?
- If the weapons are accidentally released, are there means of de-activating warheads or aborting the launch?

**Unauthorized Use**

There are a number of ways a state can reduce the vulnerability of its nuclear weapons to unauthorized use, including use-control technologies, administrative procedures, and skilled and reliable employees and guards. This study will therefore assess to what extent NWSs have implemented these command-and-control procedures and technologies.

The first requirement for a command-and-control system would be to establish a clear and reliable chain of command so that any orders from the central authorities are dutifully carried out and there is no possibility for unauthorized personnel to decide to use the weapons on their own. Guards and military officers responsible for handling the weapons must be highly disciplined and should undergo prior screening and personnel reliability testing. They should also be armed to prevent anyone from forcibly seizing the weapons.

NWSs should also have established various procedures for controlling the weapons, such as a "two-person rule," which dictates that every stage in the maintenance, deployment, and use-cycle requires the participation of at least two individuals.

Command-and-control systems that rely heavily on guard forces can work well if procedures such as the two-person rule are strictly followed, and if there is a high level of professionalism in guard forces and military officials handling the weapons, or if there are other means of guaranteeing discipline, such as authoritarian social controls. But command-and-control systems that rely heavily on guard forces can be weakened if the weapons are widely dispersed, or if the state undergoes severe economic, social, and political upheavals. In order to

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prevent the erosion of central controls under these conditions, the state should therefore have integrated use-control devices on the nuclear weapons, which require a specific code to be entered before the weapons can be launched. Of course, the specific launch codes would also need to be tightly controlled for this method to increase central controls.  

This study will therefore assess what measures NWSs have adopted to provide reliable command and control over their nuclear weapons by asking the following types of questions:

- Does each country have a clear, well-established chain of command?
- Are there loyal, armed, well-trained military forces to guard the weapons?
- Do NWSs guarantee high levels of professionalism through rigorous training and personnel monitoring programs?
- Does the country have effective procedures to reduce the risks of unauthorized use, such as a two-person rule whenever anyone must have access to the weapons?
- Is the country politically stable? Do risks of unauthorized use increase during a coup d'etat or other times of political, economic, or social upheaval?
- Are the weapons fitted with reliable use-control mechanisms that require specific codes that must be entered before nuclear-armed missiles can be armed or launched?

**Inadvertent Use**

As we have seen, both the optimists and pessimists agree that the risks of inadvertent use would be unacceptably high if emerging NWSs adopt policies that require “early firing,” such as LOW, because these policies significantly increase risks of panic-launches, false alarms, etc. Based on their respective theories, however, optimists and pessimists disagree over whether emerging NWSs actually will adopt “early-firing” policies. Optimists argue that emerging NWSs do not need to adopt such policies because survivability can be maintained through concealment and dispersal of nuclear forces, while pessimists argue that the pressures to build survivable forces will force emerging NWSs to adopt such “early-firing” policies. These arguments actually presuppose two questions. First, will dispersal and concealment ensure survivability of both nuclear forces and command structures? This dissertation will attempt to answer this question by examining current assessments of the vulnerabilities of current nuclear forces to nuclear first-strikes. And second, regardless of whether or not survivability of nuclear forces and command structures actually can be achieved through dispersal and concealment, will NWSs will be confident enough in their retaliatory capability to rely on such a policy? This is an

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94 As Peter Feaver points out, it is possible to imagine a code-management system in which the codes for the use-control devices were posted prominently on the outside of each weapon. Regardless of how advanced or sophisticated the use-control hardware might be, such a code-management system would render the use-control devices useless against unauthorized use (Ibid).
empirical question that can be verified by looking at the use doctrines that NWSs are developing or have already adopted. I will therefore attempt to answer this second question by examining the current and emerging capabilities and force doctrines in various NWSs.

But even if NWSs do appear to be moving toward rapid-response capabilities and policies of LOW, it is possible to adopt measures to make inadvertent nuclear war less likely. After all, both the United States and Russia have had policies that allowed for LOW for nearly 40 years and inadvertent nuclear war has not occurred yet. This was in part due to the presence of reliable early-warning sensors and human intelligence (HUMINT) systems; effective confidence-building measures (CBM), such as hotlines between senior officials on both sides, to reduce risks during crisis situations; and strict policies of restraint, such as avoiding direct military clashes. But it might have also been in part due to luck. This dissertation will examine, first, how successful these measures were during the Cold War. It will then examine whether emerging NWSs appear likely to adopt similar measures to reduce the likelihood of inadvertent nuclear war.

Assessing MPC&A Systems

An effective MPC&A system serves up to three different objectives:

1. Prevent the theft of nuclear materials.
2. Prevent the sabotage of a nuclear facility (or a nuclear transport vehicle).
3. Detect the theft of nuclear materials once it has occurred, and, if possible, identify those responsible for the theft.\(^{95}\)

MPC&A systems are generally divided into two distinct, though interrelated systems: Physical Protection (PP) and Material Control and Accounting (MC&A). The most straightforward aspect of MPC&A is physical protection. The ultimate purpose of a physical protection system is to prevent the theft of nuclear materials or sabotage of nuclear materials or facilities. These objectives are achieved in two ways: by deterring threats or by defeating them should groups or individuals attempt to steal nuclear materials or sabotage nuclear facilities. This deterrence is achieved by implementing a physical protection system that is perceived to be too

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\(^{95}\) For example, it will assess whether their early-warning systems experienced false alarms that could have sparked inadvertent wars.

\(^{96}\) In the context of the IAEA safeguards, MPC&A serves an additional purpose, namely detecting the diversion of nuclear materials by a given state from its peaceful nuclear program to an opaque nuclear weapons program. This issue is not directly related to this dissertation, however, and will only be briefly discussed in
difficult to overcome. And, of course, if anyone does attempt to steal materials or sabotage a facility, the physical protection system must also be able to stop the attempt. An effective physical protection system will use barriers, surveillance systems, alarms, and guards to achieve these goals.  

Unlike physical protection systems, which are intended to stop theft or sabotage attempts before they occur, current nuclear material control and accounting (MC&A) systems are used to detect a theft or diversion of nuclear materials once it has occurred. It is only possible to discover whether some materials have disappeared if one knows the exact location and amounts of nuclear materials in a given facility. The material must be effectively "controlled" through technologies and procedures intended to verify easily the precise location and storage condition of nuclear material. In addition, there must be effective "accounting" systems in place to provide "a regularly updated, measured inventory of nuclear weapons usable material, based on routine measurements of material arriving, leaving, lost to waste and remaining within the facility."  

It is important to establish specific criteria by which one might assess whether a given MPC&A system is "adequate." To develop precise standards, I rely on some of the international standards and recommendations for MPC&A established by the IAEA. In particular, INFCIRC/225/rev.4 to recommends specific standards for physical protection and INFCIRC/153 establishes standards for nuclear material control and accounting (MC&A). The following are some of the specific criteria I use to assess MPC&A systems in the NWSs. (For a more extensive discussion of IAEA-related standards for MPC&A, see Appendix A.)

**Designing and Installing MPC&A Systems**

A great deal of planning is required to design an effective MPC&A system. The first step in any such system is to determine the types and amounts of nuclear materials stored at given nuclear facilities. The specific MPC&A system will differ at each facility, depending on the

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99 Ellis and Perry, "Nunn-Lugar's Unfinished Agenda," p. 16.
“attractiveness” of the materials stored there. The following discussion presents a (very simplified) list of the steps necessary for designing physical protection and MC&A systems and for creating a safeguards culture.

Designing and Installing Physical Protection Systems

The first step in designing a physical protection system is to determine the attractiveness of given fissile materials for theft or diversion. The IAEA has established several different categories for materials stored at nuclear facilities. The specific categories range from Category I (the most attractive) to Category III, depending the type of material, its physical and chemical form, the degree of dilution, the radiation level, and the quantity of the material present. (See Appendix A, Table A.1 for the specific categories for fissile materials established by the IAEA.)

In the next step, the state should identify the specific threats that must be deterred or defeated by the facility’s physical protection system. For example, it should determine what domestic and international groups might want to target a given nuclear facility, how well-armed these groups are, and how much time it takes for external armed forces to arrive.

After identifying the potential threats, the state should design and install a physical protection system capable of defeating these threats or delaying the attacking groups until the armed forces can arrive. The IAEA recommends that the physical protection systems for facilities containing Category I materials (substantial amounts of pure plutonium or highly enriched uranium) be much more robust than for those containing Category III materials (very small amounts of Pu or HEU, or substantial amounts of low enriched uranium). (See Table 1.1 for IAEA recommendations for physical protection of Category I materials.)

Finally, after the state has designed and installed the physical protection system, it should submit the system to thorough performance testing to identify possible weaknesses in the system. These tests should include evaluations of administrative and technical measures, such as detection, assessment, and communications systems, and reviews of the implementation of physical protection procedures. Such evaluations should also include exercises to test the

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101 Because most nuclear facilities in NWSs would contain Category I materials, this chapter will only list the IAEA recommendations for Category I materials during use and storage. See Appendix A for IAEA recommendations for Category II and Category III materials.
training and readiness of guards and/or response forces. When deficiencies are identified, the state should ensure that facility operators correct the problems.102

Table 1.1: IAEA Recommendations for Physical Protection of Category I Materials During Use and Storage

During use and storage, Category I materials should be contained in at least two complete, distinct, reliable areas, an outer “protected area” and a more secure “inner area.” The following are the physical protection recommendations for each of these areas.103

**Inner area(s):**

- All Category I material should be used or stored within the inner area or inner areas.
- Access to the inner area should be restricted to employees whose duties require access to this area. These employees should carry badges demonstrating authorization.
- There should be a limited number of entrances to the inner area. All emergency exits should be fitted with alarms.
- Fissile materials should be stored in a vault in the inner area. The vault should be protected by alarms and adequate locks, and the issue of keys or key-cards should be closely controlled.
- Whenever persons are present in inner areas, those areas should be under constant surveillance. The surveillance can be effected by mutual observation between two or more co-workers (e.g. a two-person rule).
- Material should be protected by guards at all times. An external and internal patrol should be provided.

**Protected area(s):**

- The protected area should be under constant surveillance (by a guard or by electronic means). The perimeter of the protected area should normally consist of a physical barrier (a fence, wall, or a similar impediment approved by a security survey) in addition to and outside the walls of the building itself.
- Access to the protected area should be restricted to those whose duties require access to this area.
- Entry of private motor vehicles into the protected area should be minimized and limited to authorized parking areas. Private motor vehicles should be prohibited from access to inner areas.

102 For the necessity of performance testing of physical protection systems, see INFCIRC/225/rev.4, section 4.4.1 and Oleg Bukharin, Matthew Bunn, and Kenneth Luongo, Renewing the Partnership: Recommendations for Accelerated Action to Secure Nuclear Material in the Former Soviet Union, Russian American Nuclear Security Advisory Council, August 2000, pp. 79–86.

103 The requirements outlined in INFCIRC/225 are more extensive than I can describe here. I try to summarize as many of the major points as possible.
Designing and Installing MC&A Systems

The state's material accounting system must be able to measure materials moving into and out of its nuclear facilities and identify any losses. INFCIRC/153 explicitly outlines necessary requirements for establishing an accounting system at a nuclear facility. The first step in setting up this system is to identify "material balance areas" (MBAs), or key places where the amounts of nuclear material entering and exiting the facility can be measured. The state should then design a system to include the following provisions:104

- A measurement system for the determination of the quantities of nuclear material received, produced, shipped, lost or otherwise removed from inventory, and the quantities on inventory;
- The evaluation of precision and accuracy of measurements and the estimation of measurement uncertainty;
- Procedures for identifying, reviewing and evaluating differences in shipper/receiver measurements;
- Procedures for taking a physical inventory;
- Procedures for the evaluation of accumulations of unmeasured inventory and unmeasured losses;
- A system of records and reports showing, for each material balance area, the inventory of nuclear material and the changes in that inventory including receipts into and transfers out of the material balance area;
- Provisions to ensure that the accounting procedures and arrangements are being operated correctly.

The state should also have a material control system at each of its facilities to detect the unauthorized movement of fissile materials inside a facility or removal of materials from the facility. This system should employ portal monitors to detect any materials passing from storage sites and the facility itself, and secure storage containers with tamper-resistant seals and identification codes to detect whether anyone has had access to the materials.105 A control system could also include surveillance cameras and other electronic techniques to monitor and record activities in critical locations and to detect any tampering with measurement equipment or storage containers.106

104 INFCIRC/153, section II.32.
Creating a "Safeguards Culture"

For an MPC&A system to work, it is not enough just to have sensors and alarms installed at nuclear facilities. The country must have an effective "safeguards culture," or a "pervasive, shared belief among political leaders, senior managers, and operating personnel that effective MPC&A is critically important, as manifested in decisions and actions, large and small."\textsuperscript{107} This means that every individual must be willing to follow the necessary MPC&A procedures, which are often cumbersome and time-consuming. Managers at nuclear facilities must therefore be willing to sacrifice other important goals (such as meeting production timetables) when necessary in order to ensure that MPC&A is effective.\textsuperscript{108} This study will therefore assess whether current NWSs have cultivated safeguards cultures within their nuclear facilities.

What Are The Specific Variables Affecting State Action?

To the extent to which I am able to discuss each of the topics identified in this research agenda, I will be able to make a significant contribution to the proliferation debate. If it turns out that current NWSs do not have adequate controls over their nuclear arsenals and fissile material stockpiles, we will have reason to doubt that proliferating states will implement them. But because the optimism-pessimism debate is, at its most fundamental level, one over competing theories about how to explain and predict state actions, a simple assessment of whether particular states have implemented adequate controls, while valuable, is not enough to prove that either side is right. This dissertation will therefore examine the reasons why states did or did not implement rigorous nuclear controls. It will examine the following issues.

Organizational and Bureaucratic Constraints

As we have seen, optimists claim that states will have adequate nuclear controls because, as unitary, rational actors, they will clearly see it is in their interests to adopt such controls.\textsuperscript{109} Pessimists, on the other hand, argue that state action is constrained by organizational difficulties and parochial interests among various bureaucracies. This study will assess the optimist and pessimists theories by asking the following questions: If a given state \textit{did} implement rigorous

\textsuperscript{108} Ibid., p. 92.
nuclear controls, was it due to a simple rational calculation of its self-interest, as the optimists argue it will be? Was it due to external pressure from the IAEA, the United Nations, or the United States? Did all the state’s bureaucracies agree that these controls were necessary, or was there a struggle based on parochial pulling and tugging? If the state did not have adequate controls, was this due to bureaucratic parochial interests, “satisficing,” or inadequate organizational supervision? Or do other factors determine state decision-making altogether?

**Rich vs. Poor Proliferators**

In addition, in my sample, I will examine both wealthy, industrialized countries and poor, technologically under-developed countries. As we have seen, one of the central issues in the proliferation debate focuses on whether poor countries will have trouble implementing rigorous nuclear controls. I will assess the relative claims of the optimists and pessimists on this issue. The United States is a rich, industrialized country with few financial constraints. It would encounter few, if any, serious financial obstacles that would prevent it from implementing excellent nuclear controls. India and especially Pakistan are good examples of countries with limited resources. Russia and China are somewhat more complicated cases. When Russia was first developing its nuclear weapons (as the USSR), it was industrialized and relatively wealthy. Financial constraints should not have affected its implementation of rigorous nuclear controls then. But since its collapse, it has been seriously constrained financially. And while China is desperately poor in many regions, it is relatively industrialized and wealthy in others. In any case, because this dissertation examines a range of countries in various economic conditions, it will be especially useful for assessing the effects of financial resources in the implementation of nuclear controls.

**Political, Economic, and Social Instability**

A major objective of the present study is an examination of the effects of domestic upheavals on nuclear controls. As we have seen, optimists and pessimists take opposing positions on this issue. Seng argues that a politically unstable state will actually have *stronger* nuclear security, while Feaver argues that political instability will tend to weaken nuclear security. A number of the states discussed in my dissertation have undergone extreme political, economic, and social upheavals while they possessed nuclear weapons. For example, Russia has undergone very severe domestic upheavals in the years following the collapse of the Soviet
Union. China has also had a number of severe political upheavals since its first nuclear test in 1964, including the Cultural Revolution and the Tiananmen Square Crisis. And Pakistan has experienced an economic collapse in 1998 and a military coup d'état in 1999. I will examine whether the specific nuclear controls employed in the NWSs are designed so that they will remain strong during such upheavals.

**Opacity**

My study should shed some light on the debate between the optimists and the pessimists over the nuclear controls implemented by opaque proliferators. Until their nuclear tests in 1998, India and Pakistan were two of the main examples of opaque proliferators. Needless to say, this view of the two countries changed dramatically after their nuclear tests. Nevertheless, India and Pakistan possessed opaque nuclear arsenals for many years, and we can discover a great deal about how opaque proliferators operate by looking at India's and Pakistan's nuclear controls during that time. Indeed, now that they have openly declared their nuclear arsenals, more information about the arsenals has become available than before. In addition, we will now be able to examine a new and extremely important issue in nuclear proliferation: what happens when opaque proliferators become visible proliferators? As the relations between India and Pakistan during 1998 and 1999 have shown, this transition itself can cause significant regional instability. We are able to learn a great deal about the differences between opaque and visible proliferators by comparing the experiences of India and Pakistan with the three visible proliferators discussed in this dissertation (United States, Russia, and China).

**Policy Implications**

Finally, I will briefly discuss some possible policy implications for the United States and the international community, based on what we have learned from these case studies. What, in fact, should be our policy toward proliferation? If my research demonstrates that states do implement adequate nuclear controls, this might suggest that we should relax our stance against proliferation. If my research supports the pessimist position, then the United States should maintain, or possibly strengthen, its opposition to proliferation. Moreover, if this study reveals

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110 It is also questionable whether such a reversal of the U.S. stance against proliferation is even possible, given internal pressures from public opinion and external pressures from the nonproliferation regime (which the U.S. helped create).
problems with the nuclear controls in current NWSs, should the United States attempt to help them solve some of these problems? If so, what are the obstacles to such efforts?

Both the optimists and pessimists have made internally consistent arguments for their positions. It is now time to test their theories against the empirical record. Due to the highly-sensitive character of this subject, there will necessarily be information gaps in some of the case studies. Nevertheless, I believe there is enough available information to make a definitive pronouncement on the debate. The next chapter will address the strongest case for the optimist position, the United States.
Chapter 2: United States

Why Study the United States?

As we have seen in Chapter 1, optimists such as Kenneth Waltz, John Mearsheimer, and Bruce Bueno de Mesquita and William Riker have pointed to the relative stability that arose between the United States and the Soviet Union during the Cold War as a major source of evidence for their position. They therefore conclude that the U.S. case helps demonstrate that NWSs will control their nuclear weapons safely. But were the specific weapons systems and nuclear control employed by the United States as safe as the optimists assume? A number of pessimists such as Bruce Blair, Scott Sagan, and Peter Feaver have argued that it was not. Furthermore, even if the answer to this first question is “yes,” we must also assess whether the U.S. case can help us know whether emerging NWSs would be willing or able to follow the U.S. model. This chapter examines the U.S. weapons systems and nuclear controls in light of these questions to determine whether U.S. case generally supports the optimist or pessimist position.

The U.S case is also an important case for several other reasons. First, it is important because the United States has been willing to provide more information on its nuclear systems than other countries. We are therefore allowed better insight into the decision-making process on nuclear issues and into the types of actions that NWSs are likely to take. Second, because the United States has possessed its nuclear weapons the longest, we will be able to understand how—or whether—states engage in “nuclear learning.” The longer history will also allow us to look at the difficulties and obstacles that states encounter with their nuclear controls over time. Third, the U.S. case will help us examine why NWSs are motivated to develop certain types of nuclear systems and force deployments. It will therefore help us identify what factors might cause other NWSs to develop certain deployment options and nuclear systems. And finally, the U.S. case study will give us a “baseline” by which we can judge other NWSs. Unlike several of the cases we will examine, the United States is not significantly constrained by limited resources, authoritarian regimes, or “opaque” nuclear arsenals. It will therefore allow us to isolate some of these variables to determine what factors affect the nuclear controls in NWSs. The United States also provides a “baseline” because it has arguably devoted more attention to ensuring its nuclear

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controls than any of the NWSs we will be studying. As such, the United States represents the best case we can reasonably hope for among NWSs. In this study, we will therefore examine the nuclear systems in the United States to determine whether it engaged in risky procedures and whether it had adequate controls over its nuclear forces and fissile materials.

Part I: U.S. Command, Control, Communications, and Intelligence (C3I)

U.S. Nuclear Arsenal and Delivery Systems

The first nuclear weapons designed by the United States were gravity bombs, delivered by nuclear-capable bombers. The very first nuclear devices were the implosion bomb “Little Boy” and the HEU gun design “Fat Man,” which were dropped on Hiroshima and Nagasaki in 1945. After the end of World War II, the United States had components for several additional atomic bombs and several B-29 and B-50 heavy bombers configured to carry them. In 1946, the United States established the Atomic Energy Commission (AEC) to oversee the development of a “war reserve” of nuclear weapons. During the first several years, the stockpile grew very slowly, primarily due to limited fissile materials. In 1946, the stockpile had only nine weapons; in 1947 it had thirteen; and in 1948 it had fifty.

A number of factors influenced the decision to expand the stockpile more rapidly in the late 1940s and early 1950s. First, there was a growth in the supply of fissile materials, combined with several technical breakthroughs that allowed for higher yields with smaller amounts of fissile materials. Second, the United States perceived a greater Soviet threat after the Soviets tested their first nuclear weapon in 1949 and after the outbreak of the Korean War in 1950. As a result, in 1950, President Truman ordered increased production of fission devices and placed the

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2 It is possible that Great Britain and France have devoted similar attention and resources to their nuclear controls. But this might be expected, because these countries are also prosperous, liberal democracies. Thus, we might expect that they would approach their nuclear controls in the same way as the United States. This, incidentally, is one reason why this study does not examine the nuclear controls in Great Britain and France.


thermonuclear development program on a crash basis.\(^8\) By 1955, the stockpile had grown to 2,250 nuclear weapons and included both strategic and tactical weapons.\(^9\) These weapons were primarily deliverable by aircraft, though nuclear devices were also deployed on atomic artillery projectiles, some short-range missiles, and some atomic demolition units (nuclear land mines).\(^10\)

The peak production years of U.S. nuclear weapons occurred between 1955 and 1967. By 1955, the United States had sufficient fissile material production capability to sustain a rapid development of nuclear weapons. It is estimated that between 1955 and 1967, 30,000 new warheads entered the stockpile, swelling its number to over 32,000.\(^11\) The U.S. arsenal included both fission and thermonuclear weapons,\(^12\) deliverable by bombers, tactical missiles, and new strategic ballistic missiles.\(^13\)

In the mid-1960s, the United States restructured its nuclear forces. Tactical weapons began to dominate the stockpile. Strategic inventories were reduced as intercontinental ballistic missiles (ICBMs) and submarine-launched ballistic missiles (SLBMs) became operational and older bomber forces were phased out.\(^14\) The United States now had a "triad" of capabilities: long-range strategic aircraft, land-based ICBMs, and SLBMs.

The number of U.S. nuclear weapons decreased through the 1970s, primarily due to the retirement of large numbers of bombs, U.S.-based air defense warheads, and some tactical air- and sea-launched missiles.\(^15\) By the early 1980s, the U.S. nuclear arsenal had been reduced to approximately 25,000 warheads of air-, sea-, and land-based weapons systems, and atomic demolition units.\(^16\) At this point, the United States and the Soviet Union began negotiations for arms reduction treaties. The following sections will discuss the series of arms limitation and

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\(^{8}\) Ibid., p. 6.

\(^{9}\) The term "strategic" generally refers to nuclear weapons whose capability and mission is to hit the heart of an adversary's homeland. Although the range of these weapons need not always be the key factor in their definition, in the U.S.-Russian dialogue on such weapons, geographical range has been the overriding feature in attempts to delineate tactical from strategic nuclear weapons. Thus, "strategic" generally refers to long-range weapons (including ICBMs, SLBMs, and long-range bombers and their weapons), while "tactical" generally refers to short-range missiles, short-range bombers their nuclear weapons, nuclear land mines, nuclear artillery, etc.

\(^{10}\) Cochran et al., *Nuclear Weapons Databook, Vol. I.*, p. 11.

\(^{11}\) Ibid., p. 12.

\(^{12}\) The United States successfully its first test of a thermonuclear device on May 9, 1951 and tested its first operational thermonuclear bomb on May 21, 1956. For a history of the U.S. thermonuclear weapons project, see Richard Rhodes, *Dark Sun: The Making of the Hydrogen Bomb* (New York: Simon and Schuster, 1995).


reduction treaties undertaken by the United States and the Soviet Union (and later Russia) during the 1970s, 1980s, and 1990s.

**Nuclear Arms Limitation Treaties, Reduction Treaties, and Presidential Initiatives**

Recognizing the extreme dangers and economic costs of the massive arms buildups during the Cold War, the United States and the Soviet Union began negotiations in the early 1970s for limiting strategic nuclear weapons deployments. These negotiations culminated in the SALT I agreements and the SALT II Treaty. SALT I was a collection of agreements, including a treaty to limit anti-ballistic missile systems (the ABM Treaty)\(^\text{17}\) and an Interim Agreement to limit strategic offensive arms. SALT II, on the other hand, was a treaty that limited the weapons on each side to specific numbers. Although both sides observed the SALT II limits, it was never officially ratified by the U.S. Senate.\(^\text{18}\)

**INF Treaty**

In 1983, U.S. President Reagan and Soviet Premier Brezhnev began negotiations on a treaty to remove intermediate-range missiles from their forces. These negotiations gained momentum in 1984 after Mikhail Gorbachev came to office, and both sides signed the Intermediate-range Nuclear Forces (INF) Treaty in 1987. The INF Treaty required complete elimination of all deployed U.S. and Soviet land-based missiles with ranges of 300 to 3400 miles and banned production, storage, or deployment of such systems thereafter. The treaty also established a system of on-site inspections to verify that each side complied with INF regulations.\(^\text{19}\)

**START I**

Negotiations for the first Strategic Arms Reduction Treaty (START I) began in 1982 and were completed in the early 1990s. Both sides signed the treaty on July 31, 1991, but it did not enter into effect until 1995. START I limits each side to 1,600 strategic delivery vehicles, and a

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\(^{17}\) While the ABM treaty forbids the United States and the Soviet Union from creating a national missile defense, it does not ban all antiballistic missile systems. The original treaty permitted each side to build two operational ABM sites, each with 100 ABM launchers and 100 interceptor missiles, with associated radar, storage, and test facilities, but a 1974 amendment reduced the number of permitted operational ABM sites to one per side. For the texts of the 1972 treaty and the subsequent amendment, see <http://www.state.gov/www/global/arms/treaties/abm/abm3.html>.


\(^{19}\) Ibid.
total of 6,000 accountable warheads for those delivery vehicles. In addition, the treaty requires a reduction of deployed heavy ICBMs, namely the Soviet SS-18s, from 308 missiles to 154.20

1991–1992 Presidential Nuclear Initiatives (PNIs)

On September 27, 1991 President Bush announced a series of arms reduction initiatives that were intended to reflect the changing security environment brought about by the end of the Cold War. These initiatives included the withdrawal of U.S. Army nuclear weapons from overseas bases and the elimination of approximately 3000 artillery shells and short-range Lance missile warheads.21 Bush also directed the withdrawal of tactical nuclear weapons from surface ships and attack submarines and the elimination of numerous naval tactical nuclear weapons.22 In response to these initiatives, Russian President Michael Gorbachev announced a similar series of nuclear arms reduction initiatives later in 1991. In 1992, Russian President Boris Yeltsin announced reductions that were in line with (but differed from) those of his predecessor.23

START II and START III

In 1992 Presidents Bush and Yeltsin began negotiations for a further reduction of strategic nuclear weapons and both sides signed the START II treaty in January 1993.24 START II provides for the reduction of total deployed warheads to 3,500 by 2003, and requires the complete removal of ICBMs with multiple independently-targetable re-entry vehicles (MIRVs). It also limits the total warheads deployed on submarine-launched ballistic missiles (SLBMs) to 1,750 for each side.25 (See Table 2.1 for the proposed strategic weapons reductions under START II.) At the conclusion of their Helsinki meeting in March 1997, Presidents Bill Clinton and Boris Yeltsin agreed to extend the deadline for elimination of strategic delivery vehicles under START II to December 31, 2007, but stipulated that these systems must be deactivated by December 31, 2003.26 They also agreed to begin negotiations on a START III treaty

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20 Ibid., p. 3.
22 Ibid., p. 9.
23 For a discussion of the Russian PNIs, see Chapter 3, p. 93.
24 Thomson, The START Treaties, p. 3.
25 Ibid., p. 8. There are complicated counting rules for nuclear weapons deployed on heavy bombers. According to START II, "each bomb, short-range attack missile (SRAM), or air launched cruise missile (ALCM) for which each type of bomber is actually equipped counts as one warhead" (ibid., p. 8).
immediately after START II’s entry into force, which would limit deployed strategic forces on both sides to 2,000–2,500 warheads.27

Although the U.S. Senate ratified START II in January 1996, the Russian Duma delayed consideration of START II several times in the late 1990s, including delays in January 1998 in protest over the bombing of Iraq by the United States and Great Britain and in 1999 in protest over NATO bombing of Yugoslavia. The Duma finally ratified START II on May 4, 2000, shortly after the election of Russian President Vladimir Putin.28 The Duma’s ratification of START II was contingent on the United States not abrogating the ABM Treaty, however. The Duma’s condition has delayed START II’s entry into force and may permanently prevent it, since the United States is determined to create a national missile defense (NMD), which necessitates modifying or abrogating the ABM treaty.29 The controversy over the proposed U.S. missile defense system has also become a major obstacle to negotiations on START III.30

| Table 2.1: U.S. Strategic Force Reductions in Accordance with START I & II |
|---------------------------------|----------|-----------------|-----------------|
| ICBMs                           |          |                 | 1,000            | 550  |
| Attributed Warheads on ICBMs    |          |                 | 2,450            | 2,000 |
| SLBMs                           |          |                 | 568⁹             | 432⁸ |
| Attributed warheads on SLBMs    |          |                 | 4,864⁹           | 3,456⁸ |
| Ballistic Missile Submarines    |          |                 | 31⁹              | 18¹⁰ |
| Attributed Warheads on Ballistic Missiles |    |                 | 7,314⁹          | 5,456⁸ |
| Heavy Bombers                   |          |                 | 324              | 115⁹ |

a. Excludes five decommissioned submarines (and their associated missiles and warheads) that were still START accountable.
b. Excludes two Benjamin Franklin-class SSBNs converted to Special Operations Forces that are still START accountable.
c. Excludes 93 B-1s that are devoted entirely to conventional missions. B-1s are still accountable as a nuclear bomber under START I, but would not be accountable under START II.
Source: Federation of American Scientists, “United States Nuclear Forces.”

30 Ibid., p. 41.
Current U.S. Nuclear Forces

As of March 2001, the total U.S. nuclear stockpile consisted of about 10,000 weapons. Of these weapons, approximately 7206 are operational, while the remaining weapons are retained in an “inactive” or “hedge” stockpile to provide extra warheads for reconstitution of part of the force in case arms control expectations failed to materialize. Some number of these nuclear warheads are still awaiting removal from the U.S. forces in accordance with START II. In particular, to comply with START II ban on MIRVs, each Minuteman ICBM will have the number of warheads it carries reduced from three to one and all MX ICBMs will be retired by 2007. (See Table 2.2 for a list of current U.S. nuclear forces.)

Table 2.2: U.S. Strategic Forces, 2001

<table>
<thead>
<tr>
<th>Type</th>
<th>Name</th>
<th>Launchers/SSBNs</th>
<th>Year Deployed</th>
<th>Warhead x Yield (kiloton)</th>
<th>Total Warheads</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICBMs</td>
<td>LGM-30G Minuteman III:</td>
<td>200 300</td>
<td>1970 1979</td>
<td>3 W62 x 170 (MIRV) 3 W78 x 335 (MIRV)</td>
<td>600 900</td>
</tr>
<tr>
<td></td>
<td>Mk-12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mk-12A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LGM-118A MX/Peacekeeper</td>
<td>50</td>
<td>1986</td>
<td>10 W87 x 300 (MIRV)</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>350</td>
<td></td>
<td></td>
<td>2,000</td>
</tr>
<tr>
<td>SLBMs</td>
<td>UGM-96 A Trident I C-4</td>
<td>192/8</td>
<td>1979</td>
<td>B W76 x 100 (MIRV)</td>
<td>1,536</td>
</tr>
<tr>
<td></td>
<td>UGM-133A Trident II D-5</td>
<td>216/10</td>
<td>1992</td>
<td>B W76 x 100 (MIRV)</td>
<td>1,536</td>
</tr>
<tr>
<td></td>
<td>Mk-4</td>
<td></td>
<td>1990</td>
<td>B W88 x 475 (MIRV)</td>
<td>384</td>
</tr>
<tr>
<td></td>
<td>Mk-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>408/18</td>
<td></td>
<td></td>
<td>3,456</td>
</tr>
<tr>
<td>Bombers</td>
<td>B-2 Spirit</td>
<td>21/16</td>
<td>1994</td>
<td>ALCM/W80-1 x 5–150 B61-7/1-11, B83 Bombs ACM/W80-1 x 5–150 (totals for all bombers)</td>
<td>400 950 400</td>
</tr>
<tr>
<td></td>
<td>Stratofortress</td>
<td>76/56</td>
<td>1961</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>115/72</td>
<td></td>
<td></td>
<td>1,750</td>
</tr>
<tr>
<td>Non-Strategic Forces</td>
<td>Tomahawk SLCM</td>
<td>325</td>
<td>1984</td>
<td>1 W80-0 x 5–150</td>
<td>320</td>
</tr>
<tr>
<td></td>
<td>B61-3,4,10 bombs</td>
<td>n/a</td>
<td>1979</td>
<td>3–170</td>
<td>1,350</td>
</tr>
</tbody>
</table>


33 The first number represents the total inventory. The second number is the “primary mission” number, which excludes trainers and spares.
34 Bombers are loaded in a variety of ways, depending on their mission. B-2s do not carry ALCMs or ACMs. The first 16 B-2s initially carried only the B83 bombs. Eventually, all 21 B-2 bombers will be able to carry both B61 and B83 bombs.
**Nuclear Weapon Storage and Deployment**

Since 1992, the United States has been consolidating its nuclear forces. As of 1998, it had withdrawn nuclear weapons from 13 states and stored its nuclear weapons at 24 main depots in 14 states. The United States currently deploys 200 Minuteman ICBMs at Malmstrom Air Force Base (AFB) in Montana; 150 Minuteman ICBMs at Minot AFB, North Dakota; and 150 Minuteman ICBMs and 50 MX missiles at Warren AFB in Wyoming. Eighteen ballistic missile submarines (SSBNs) operate from bases in Georgia and Washington, with approximately two-thirds at sea at any given time.

At the height of the Cold War, the United States also deployed approximately 10,311 nuclear weapons in 17 foreign countries. Since the end of the Cold War, the United States has withdrawn these weapons from many of these countries. As of 2001, it still deployed approximately 150 nuclear weapons at ten U.S. bases in seven countries (Germany, the United Kingdom, Turkey, Italy, Greece, Netherlands, and Belgium). All of these weapons are B61 strike bombs, controlled by the U.S. Air Force.

The only facility for assembly and disassembly of U.S. nuclear weapons is the Pantex Plant, located 17 miles northeast of Amarillo, Texas. Due to the major weapons reductions in the last decade, the United States has been retiring about 1,300 warheads per year. Approximately 350 nuclear weapons are present at this facility at any given time, though most of these weapons are awaiting dismantlement. Between October 1986 and September 1996, Pantex disassembled 12,514 warheads. At the end of 1997, there were approximately 10,750 “pits”—the nuclear cores of dismantled warheads—in storage at Pantex.

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38 ibid., p. 16.
40 Arkin et. al., *Taking Stock*, p. 68.
41 Ibid., p. 69.
The U.S. C³I System

Launch-on-Warning (LOW)

As the vulnerabilities of decapitation or destruction of large numbers of nuclear U.S. forces increased, the U.S. command system became increasingly geared toward the capability for launching the majority of the nuclear forces before Soviet weapons reached their targets. By the early 1980s, official U.S. policy therefore reportedly allowed for the option of launch-on-warning (LOW). Although this policy allowed for greater survivability of U.S. forces, it significantly increased the requirements for C³I. The option of LOW required that the majority of U.S. nuclear forces be placed on high alert, which allowed the weapons to be launched within fifteen minutes from detection of an incoming Soviet attack. It also required a high reliance on early-warning sensors to detect an attack and a command system that could disseminate a launch command very rapidly. At the same time, precautions had to be taken to ensure adequate command-and-control over the nuclear forces to prevent accidental or unauthorized use. The following sections discuss the C³I system that evolved to provide simultaneously the dual needs of operational readiness and command-and-control.

Early-Warning Systems

In order to ensure that it could detect an incoming Soviet attack, the United States developed an intricate system of early-warning sensors to observe the launching and transit of Soviet strategic delivery vehicles. In the early 1950s, the United States constructed an extensive chain of radar installations in Alaska, Canada, and Greenland to detect Soviet bombers en route to North America. The United States later expanded its early-warning radar system in the 1960s to include over-the-horizon backscatter (OTH-B) radars, which bounce their radio signals from the ionosphere and thus are able to detect objects at much longer distances.

As the Soviets developed ICBM capabilities in the 1950s and 1960s, the United States also constructed a ballistic missile early warning system (BMEWS), which employed radars to detect incoming ballistic missiles. These radars were located at three main sites along Soviet ICBM corridors: Clear, Alaska; Thule, Greenland; and Fylingdales, England. The United States later expanded and improved its BMEWS to detect possible Soviet SLBM launches. This new system employed long-range phased array radars (called PAVE PAWS) located on the east and west coasts.

The United States also developed an advanced early-warning system, known as Defense Support Program (DSP), which uses satellites to detect infrared energy radiated from the exhaust of a missile’s rocket engine launched from anywhere on the Earth’s surface. For most of the DSP’s history, three geostationary satellites provided continual surveillance of most of the Earth’s surface. The current DSP system reportedly employs five geostationary satellites, with the two extra satellites providing additional surveillance of areas of concern, particularly Russia and China. These additional satellites allow for greater accuracy in determining missile launch trajectories.

The information from the satellites and the PAVE PAWS radars is forwarded to Cheyenne Mountain Air Station in Colorado Springs, the National Military Command Center, and the U.S. Strategic Command (STRATCOM). The data from all other early-warning sensors is fed only to Cheyenne Mountain, which serves as the primary center for North American Aerospace Defense Command (NORAD), the organization responsible for assessing and processing early-warning information. If the early-warning centers at NORAD determined that an attack might be headed toward the United States or its allies, they would notify the Commander-in-Chief of NORAD (CINCNORAD) at the nearby Peterson AFB. If CINCNORAD were also to determine the possibility of an attack, he or she would then convene

44 For a detailed discussion of U.S. BMEWS, see ibid., pp. 293–299.
45 PAVE PAWS stands for “precision acquisition of vehicle entry phased-array warning system.”
48 Geostationary satellites stay above one spot on the Earth. They orbit at a distance of 37,000 km from the surface of the Earth so that they complete one orbit in 24 hours.
50 “PAVE PAWS Radar System”; Senator Gary Hart and Senator Barry Goldwater, Recent False Alerts from the Nation’s Missile Attack Warning System, U.S. House of Representatives, Committee on Armed Services, 96th Cong., 2nd session, October 9, 1980, p. 3.
a “threat assessment conference” with more senior personnel, such as the Chairman of the Joint Chiefs of Staff. If the threat were to persist, the final action would be to convene a “missile attack conference,” which brings in all senior personnel including the president to decide on U.S. options.

**Command Structure**

Under normal circumstances, the U.S. president is the only person authorized to command the use of nuclear weapons. If the president were to decide to use nuclear weapons, he or she would order the decision to be transmitted down the chain of command, from the secretary of defense, through the chairman of the Joint Chiefs of Staff and to the appropriate and specified commanders in chief (CINC). The president would then transmit the launch order from his black bag “football,” which follows the president at all times. The football presumably contains authenticating codes, which identify the launch command as emanating from him, and possibly the enabling codes necessary for launching U.S. nuclear weapons. In order to prevent a decapitation strike, however, the authentication and enabling codes are almost certainly held at other layers in the chain of command. If the President were to issue a launch command, he would presumably activate the football by a code card that he carries on his person.

At this point, the order from the National Command Authority would be relayed to the U.S. Strategic Command (USSTRATCOM), which would pass the order to the U.S. alert forces. In the event that the underground USSTRATCOM center became inoperable, control of strategic forces would be transferred either to the CINC Mobile Consolidated Command Centers (MCCCs), consisting of a series of hardened shelters mounted on semi-trailers, or to the USSTRATCOM Airborne Command Post, which is ready to become airborne 24 hours a day.

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51 Hart and Goldwater, *Recent False Alerts*, p. 5.
55 Ibid., p. 38. After the 1981 assassination attempt on President Reagan, the Federal Bureau of Investigation accidentally carried off this card along with Reagan’s clothes (ibid., p. 38., n.19).  
Line of Succession

If the President were incapacitated or killed, the authority to order the use of nuclear weapons would be transferred down a specified chain of command. The line of succession for the presidency is clearly established by the Constitution and subsequent succession laws passed by Congress. The current succession order is the following: vice-president, Speaker of the House, president pro tempore of the Senate, and the cabinet secretaries in chronological order of establishment of their departments. In order to prevent the elimination of the entire line of succession, current U.S. procedures prevent all of these people from being in the same place at a given time. In the event of a decapitation strike that killed a number of the people in the line of succession, however, it is likely that this line of succession would be preempted at some point by the National Command Authority (NCA), which includes, in order, the president, secretary of defense, and the Chairman of the Joint Chiefs of Staff.

Predelegation of Launch Authority

A number of scholars have argued that U.S. presidents, beginning with Dwight D. Eisenhower, delegated to key military commanders the authority to use nuclear weapons under certain circumstances. This “predelegation” of launch authority would enable the United States to respond with nuclear weapons even if the President were unable to order their use in a timely manner. In particular, predelegation would allow the United States to retaliate in the event of a surprise Soviet attack that “decapitated” the civilian command authority.

Recently de-classified documents in the National Security Archive confirm that Eisenhower did approve predelegation instructions in late 1959 to the Commanders-in-Chief of the Atlantic Command, European Command, and Strategic Air Command. These instructions authorized commanders “to expend nuclear weapons in defense of the United States, its Territories, possessions and forces when the urgency of time and circumstances does not permit a specific decision by the President or other person empowered to act in his stead.”

Other de-classified documents in the National Security Archive indicate that Presidents Kennedy and

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57 Ibid. For the specific order of the cabinet secretaries, see ibid., pp. 41–42.
58 Ibid., p. 45.
59 Blair, Logic of Accidental Nuclear War, p. 46, Feaver, Guarding the Guardians, pp. 47–54.
61 Ibid.
Johnson adopted predelegation instructions that were "basically the same" as Eisenhower's.\textsuperscript{62} Information on predelegation arrangements made by President Johnson after March 1964 or by his successors remains classified, but Bruce Blair cites some evidence suggesting that predelegation continued at least through the late 1980s.\textsuperscript{63}

**Control Structure: Security Procedures and Use-Control Devices**

In order to help prevent thefts or unauthorized use of its nuclear weapons, the United States developed a number of procedures and use-control devices for its nuclear weapons. One such measure was implementing a Personnel Reliability Program (PRP) to ensure that only individuals who meet the highest suitability and reliability standards are assigned to nuclear duty positions.\textsuperscript{64} In addition, the United States strictly enforces a "two-person rule," which requires a minimum of two authorized personnel to be present during any functions where people come into contact with nuclear weapons or code materials related to their release.\textsuperscript{65}

As the number of nuclear weapons deployed in Europe increased, the United States began exploring ways to ensure control over nuclear weapons committed to NATO use.\textsuperscript{66} To this end, the United States reportedly developed a "two key" system for NATO weapons, so that two people would be necessary to launch any of these weapons. One key was to be in possession of a European officer and one was to be in the possession of a U.S. officer. There proved to be problems with this system, however. In June 1959, Congressman Charles Porter reportedly visited a Thor missile base at Feltwell, England and found that the British missile control officer possessed both keys necessary for launching the weapons.\textsuperscript{67} In addition, the United States reportedly feared that if major divisions were to emerge among NATO countries, a European country could take the U.S. officer's key by force.\textsuperscript{68}

These concerns prompted the United States to try to ensure more effective decoupling of the possession of U.S. nuclear weapons from the ability to use them. In 1958 and 1959 Fred Iklé of the U.S. Air Force Project at RAND had recommended that a "combination lock" be placed

\textsuperscript{62} Ibid.
\textsuperscript{63} Blair, *Logic of Accidental Nuclear War*, p. 50.
\textsuperscript{64} Cotter, "Peacetime Operations," p. 61.
\textsuperscript{66} The improved controls were intended to provide assurances to both the United States and its NATO allies that all the weapons deployed in Europe were adequately controlled.
\textsuperscript{68} Ibid., p. 225.
on U.S. nuclear weapons. At about the same time, John Foster of Lawrence Livermore National Laboratory (LLNL) and Harold Agnew of Los Alamos National Laboratory (LANL) were proposing improved safety and control measures for U.S. nuclear weapons. When the Joint Committee on Atomic Energy became concerned about the security of nuclear forces deployed in Europe, U.S. laboratories had already designed prototypes for electro-magnetic, remote-controlled combination locks to be inserted into the nuclear weapon circuitry. The first versions of these locks were incorporated into bombs and missiles, while the Army-fired atomic projectiles were stored in special storage containers with rugged standard combination locks. In 1962, President Kennedy issued National Security Memorandum 160, which required more effective PAL designs to be placed on nuclear weapons based in Europe.69

There are reportedly several different PAL designs on U.S. nuclear weapons, known as Category (CAT) A, B, D, and F. CAT A PALs were the first electromechanical, remote-controlled locks. The mechanism was inserted into the arming circuits for the weapon and prevented it from being activated until the proper four-digit enabling code was inserted. To insert the code, a portable control box is attached to the weapon and a dual code is inserted by a two-person team. CAT B PALs are similar to CAT A, but were reportedly built with a greater economy of input wires, which also allowed them to be controlled from an airplane cockpit. The CAT D PAL was completed in the mid to late 1970s. It incorporates a six-digit coded switch and a “limited try” feature, which irreversibly locks the switch if the wrong code is entered too many times.70 CAT F PALs appear to be similar to CAT D PALs, but require a 12-digit code.71


71 Norris and Arkin, “U.S. Nuclear Weapons Safety and Control Features,” p. 48; Bellovin, “Permissive Action Links.” Donald Cotter, however, does appear to suggest that CAT F PALs are theoretically impossible to bypass, which might imply that they incorporate more advanced electronic information processing. See Cotter, “Peacetime Operations,” p. 49 and Bellovin, “Permissive Action Links.” Although CAT F PALs were incorporated into Pershing II missiles, ground-launched cruise missiles, and new gravity bombs and lay-down bombs, most of these weapons have been removed from the U.S. arsenal. Most available information suggests that no current U.S. nuclear weapons contain CAT F PALs. See Table 3 below.
Newer warhead designs also reportedly included a membrane that could detect penetration or entry attempts and disable the weapon.\textsuperscript{72}

The military at first opposed the incorporation of PALs into nuclear weapons because they thought it would reduce operational readiness.\textsuperscript{73} Nevertheless, in 1967, the United States decided to extend the use of PALs to weapons carried by Strategic Air Command (SAC) bombers.\textsuperscript{74} Nuclear-capable aircraft were fitted with an “Aircraft Monitoring and Control” (AMAC) system, which permits the pilot to monitor and control a nuclear weapon’s safety systems as well as its arming and fusing. PAL codes are transmitted through AMAC.\textsuperscript{75}

The United States also reportedly placed use-control devices, called Permissive Enable Systems (PESs), on its ICBMs in the late 1970s. According to Peter Feaver, this system is similar to PALs, with one difference: “Whereas PALs block the nuclear detonation in a bomb or artillery shell, PES inhibits a missile launch and does not affect the nuclear warhead at all.”\textsuperscript{76}

The PES prevent a launch crew from launching the ICBMs until they insert a specific code. This code is presumably tightly controlled and transmitted to the launch crews along with the launch command.\textsuperscript{77} In addition, U.S. ICBMs reportedly also contain a launch control system called a “Dual Launch Control Center” (LCC), which requires that when a two-member ICBM crew transmits a launch signal, another crew in the squadron must confirm the signal before the launch can take place.\textsuperscript{78}

For many years, however, PALs (or their equivalents) were not incorporated into weapons deployed on Navy ships or submarines because the Navy argued that the SLBM force could become ineffective if command centers were destroyed or if communications to submarines were interrupted.\textsuperscript{79} During this time, unauthorized launches were reportedly prevented by a series of procedures that involved most of the submarine crew.\textsuperscript{80} According to open-source reports, if a transmission to launch naval nuclear weapons were received, the

\textsuperscript{72} Cotter, “Peacetime Operations,” p. 49.
\textsuperscript{73} Ibid., p. 49; Stein and Feaver, Assuring Control of Nuclear Weapons, p. 12.
\textsuperscript{74} Stein and Feaver, Assuring Control of Nuclear Weapons, p. 74.
\textsuperscript{75} Norris and Arkin, “U.S. Nuclear Weapons Safety and Control Features,” p. 48
\textsuperscript{76} Feaver, Guarding the Guardians, p. 210. See also Stein and Feaver, Assuring Control of Nuclear Weapons, p. 60 and Shaun Gregory, The Hidden Cost of Deterrence: Nuclear Weapons Accidents (Washington: Brassey’s. 1990), p. 34.
\textsuperscript{77} Federation of American Scientists, “Introduction” in Special Weapons Primer.
\textsuperscript{79} Stein and Feaver, Assuring Control of Nuclear Weapons, p. 74.
\textsuperscript{80} Cotter, “Peacetime Operations,” p. 52.
transmission would be announced to the entire crew and verified by two teams of officers. Special keys would then be issued to those responsible for pre-launch and launch sequences, so that a series of "permission" switches could be closed in a prescribed sequence. The entire crew would be informed of each step in these procedures. 81

In 1992, however, the Department of Defense's Commission on Fail-Safe and Risk Reduction (FARR) recommended that PALs or PAL-equivalents be incorporated into all U.S. nuclear forces, including naval nuclear weapons. 82 The 1995 Department of Defense Nuclear Posture Review indicated that continued implementation was needed for completing the Trident Coded Control Device (CCD) and providing for system-level CCDs or PALs on all U.S. nuclear weapons by 1997. 83 These provisions were reportedly implemented in either 1996 or 1997. 84 Once CCDs were placed on the Trident SLBMs, all nuclear weapons in the U.S. arsenal reportedly contained PALs or equivalent use-control devices.

**Risks of Accidental Use**

In the early years of its nuclear weapons program, the United States ensured that the risks of accidental detonation were small by keeping the fissile materials separated from the non-nuclear detonation devices during storage and transportation. The nuclear weapons reportedly had a separable capsule containing the fissile materials. Crew members would insert this capsule into the bomb during flight. This early system was cumbersome and time-consuming, however, and required the crew to manhandle the materials into place. 85 In the early 1950s, an automatic in-flight insertion (IFI) component was developed that allowed the crew to insert the capsule automatically during flight. 86

The United States changed this system once it began producing hydrogen bombs and tactical nuclear weapons in the early 1950s. Hydrogen bombs require reliable fission devices as triggers for the larger fusion detonations. In order to make the yields of fission devices more

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81 Ibid., p. 52.
83 Ibid., p. 9.
85 Cotter, "Peaceetime Operations," p. 27.
reliable and predictable, scientists at LANL devised a technique called "boosting." In a boosted device, a mix of deuterium and tritium gases is introduced into the nuclear system, which produces higher, more reliable yields. This process, however, required a "sealed pit design," where the nuclear materials are permanently positioned within the high explosives. As a result, the safety precaution of separating the fissile materials from the high explosives had to be abandoned and other means for preventing accidental detonations and accidental launches had to be found.87

*Risks of Accidental Detonation*

In order to reduce the likelihood of accidental detonations of the sealed-pit designs, safety systems were reportedly incorporated into the warhead and bomb electrical systems.88 For instance, the firing signals were kept away from the critical components by an air gap and critical cables were isolated from each other. These designs were intended to prevent the transmission of any accidental signals to detonate the warhead.89 Pre-flight operations reportedly included pre-arming the warheads by inserting arming plugs; removing "safing" wires that prevent closure of release switches; and connecting "pull-out wires" that pull out when the bomb is released, activating the switches. Prior to release of the bomb, the pilot would activate a reversible arm-safe switch. Other safety devices included environmental sensing devices (ESDs), which automatically arm the bomb only after certain environmental conditions are met. These conditions are only produced by the flight of a bomb, such as close-to-zero accelerations, changes in barometric pressures, and decelerations from the bomb's parachute.90 One of the most important safety designs incorporated into U.S. nuclear weapons was the "one-point safety" design. In a one-point safety design, if the weapon's high explosive is detonated at any single point, the probability of producing a nuclear yield exceeding four pounds TNT equivalent is less than one in a million.91

90 Cotter, "Peacetime Operations," p. 43; Stein and Feaver, Assuring Control of Nuclear Weapons, pp. 8, 22–24; Blair, Logic of Accidental Nuclear War, p. 107.
During the 1950s and 1960s, a series of accidents involving nuclear weapons reportedly focused the debate on nuclear weapons safety. The most serious of these reported accidents involved the U.S. bomber forces, a large percentage of which were constantly in flight in case the Soviet Union launched a pre-emptive strike against the United States or its allies. The following are a few of the most famous reported accidents:

- **Kirtland AFB, NM:** On May 22, 1957, while a B-36 bomber was approaching the base at an altitude of 1,700 feet, a bomb fell from its bomber bay, taking the bay doors with it. The high explosive in the weapon reportedly detonated on impact, completely destroying the weapon and making a crater approximately 25 feet in diameter and 12 feet deep. Both the weapon and the capsule (containing the fissile materials) were on board the aircraft, but the capsule was not inserted. A nuclear detonation was not possible.

- **Florence, South Carolina:** On March 11, 1958, a bomber from Hunter AFB accidentally jettisoned an unarmed nuclear weapon because of a malfunction of the plane’s bomb-lock system. The weapon’s conventional explosive detonated on impact, but no capsule of nuclear materials was present on the aircraft.

- **Goldsboro, NC:** On January 24, 1961, during a B-52 airborne alert, the structural support of the right wing of a bomber collapsed, which ultimately caused two weapons to separate from the aircraft during aircraft breakup at 2,000 to 10,000 feet altitude. One bomb parachute opened and the weapon received little damage from impact. The other bomb broke apart on impact, though no explosion occurred.

- **Palomares, Spain:** On January 17, 1966, a B-52 and KC-135 collided during a routine high altitude air refueling. Both aircraft crashed. The B-52 was carrying four nuclear weapons. Two bombs were recovered, but the high explosives on the other two bombs exploded on impact, scattering low-level radiation over a small area.

- **Thule, Greenland:** On January 21, 1968, a B-52 crashed and burned seven miles from the runway of Thule AFB, Greenland. The bomber carried four nuclear weapons, all of which were destroyed by fire. Some radioactive contamination occurred from the accident.

The U.S. government reportedly learned some important lessons from these accidents. First, the majority of the serious nuclear weapons accidents involved the airborne alert of the B-
52 bomber force. Although the Defense Department had already planned to discontinue routine airborne alert because the U.S. ICMB force was making such alerts unnecessary, these accidents (particularly the 1966 Palomares accident) reportedly caused the DOD to cancel the peacetime B-52 airborne alerts earlier than planned.99 Second, weapons designers learned that accidents frequently mimic the delivery method for the weapons. Safety devices would therefore need to prevent accidental detonations under conditions that were similar to weapons' delivery methods. And third, designers reportedly learned that wire insulation and printed control boards become unpredictable during fires, and it therefore becomes relatively "easy" to get electrical charges across the terminals of a safety device.100

As a result, weapons designers renewed their efforts to design safety devices that would prevent accidental detonations in all abnormal environments. Because a number of the accidents involved fires, Lawrence Livermore and Los Alamos National Laboratories developed a high explosive that is less sensitive to abnormal environments, called insensitive high explosive (IHE). Although the "one-point safety" designs make it highly unlikely that a detonation of the high explosive would result in a significant nuclear yield, such a detonation could result in the spread of radiation, or in more severe cases, in the release of a deadly plutonium aerosol.101

Because IHE is less powerful than the HE used in older weapons, however, it was reportedly not used in the W88 warhead in order to maximize the military capabilities of the Trident II SLBM.102

LANL and LLNL also developed fire resistant pits (FRPs).103 In an FRP, the plutonium is encased in a metal shell with a high melting point, designed to withstand exposure to a jet fuel fire of 1,000 degrees Celsius for several hours. Because FRPs are only useful if the high explosive does not explode, they are most likely to be effective in weapons equipped with IHE. In addition, FRPs would probably not be able to withstand rocket-propellant fires, which generally burn much hotter than aircraft fuel fires.104

100 Plummer and Greenwood, "History of Nuclear Weapon Safety Devices," p. 3.
Enhanced Nuclear Detonation Safety (ENDS) System

In 1972, Sandia National Laboratories developed the Enhanced Nuclear Detonation Safety (ENDS) system, which isolates the electrical elements critical to detonation, to prevent premature arming of a nuclear weapon subjected to abnormal conditions.\textsuperscript{105} In the ENDS system, the critical components are to be isolated from their surroundings by placing them within an energy barrier. The barrier blocks all forms of energy at levels sufficient to cause a nuclear yield of greater than the equivalent of four pounds TNT. When the proper signal is transmitted, an "energy control element" is opened to allow energy into the exclusion region.\textsuperscript{106}

Second, the deliberate action that passes through the barrier must be incompatible with naturally occurring signals, energy types, or levels. In order to open the energy control element, a complex pattern of binary pulses is transmitted, which opens the lock for the energy control element. Typically, U.S. nuclear weapons contain two safety devices and each safety device is operated with a different binary pattern.\textsuperscript{107}

And, third, some of the components needed for nuclear detonation must become inoperable in the event of an accident.\textsuperscript{108} At some level of exposure to abnormal environments, the barrier becomes ineffective. In such events, the nuclear device is reportedly designed so that certain key components are more vulnerable to abnormal environmental conditions than others. Under such conditions, these components, known as "weaklinks," will become irreversibly inoperative.\textsuperscript{109} "Stronglinks," on the other hand, are the components necessary for safing and arming the weapon, and are designed to withstand severe environmental conditions.\textsuperscript{110} The combination of weaklinks and stronglinks helps ensure that the components necessary for detonating the weapon fail before the strong links do, ensuring that the weapon "fails safely."

For example, capacitors are generally used as weaklinks and are designed to melt at relatively low temperatures. Thus, in the event of a fire, the weaklinks will melt before the safety device or the barrier fails from thermal exposure, thereby rendering the weapon inoperative.\textsuperscript{111}

\begin{footnotes}
\footnote{105} Ibid., p. 49.
\footnote{106} Plummer and Greenwood, "History of Nuclear Weapon Safety Devices," p. 3.
\footnote{107} Ibid., p. 3.
\footnote{108} Ibid., p. 3.
\footnote{110} Ibid., p. 46.
\footnote{111} Plummer and Greenwood, "History of Nuclear Weapon Safety Devices," p. 3.
\end{footnotes}
Possible Continuing Safety Problems (1990–present)

Although the above list of safety devices and designs is very impressive and provides very high safety standards for U.S. weapons, some of the weapons in the U.S. arsenal reportedly do not contain all of these safety devices. As a result, several Congressional studies in the 1990s determined that some parts of the U.S. arsenal did not meet the most modern safety standards. In Congressional testimony before the Drell Committee on Nuclear Safety, the Directors of the three weapons laboratories heads testified about continuing safety problems with the short-range nuclear attack missile, SRAM-A. The Drell report criticized the United States for retaining weapons in its arsenal that did not meet the safety standards established in 1968. In light of this testimony, the United States soon discontinued the SRAM-A. But the Drell Committee also identified problems with the W76 and W88 warheads, which are used on the Trident I and II SLBMs. According to the Drell report, in order to maximize the range of the missiles with their full payloads (up to 8 warheads), neither of these warheads contains HE or FRPs.

In addition, the Drell report also argued that there was a potential safety problem with the propellant for the Trident I and II missiles. In order to maximize their range, these missiles use a propellant that could detonate, rather than simply ignite. The Trident missiles carry up to 8 warheads that are adjacent to and surround the third-stage rocket motor (in order to meet the geometric constraints of a submarine hull and at the same time achieve maximum range). The report concluded that if the third-stage motor were to detonate in a submarine loading accident, it might detonate the high explosive surrounding the nuclear pit in one or more of these nuclear warheads and lead to plutonium dispersal or possibly to a nuclear yield.

In a follow-up report to Congress, R. E. Kidder reported that some procedural precautions were undertaken to alleviate some of the potential dangers identified in the Drell report. In particular, a procedural change was made in the manner in which the Trident missiles are loaded onto submarines. "The warheads are no longer mated to the missile until after the missile has been loaded into the launch tubes. This eliminates the possibility that the accidental detonation

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112 The report argued, "For too long in the past the U.S. has retained older weapons that fail to meet the safety criteria proclaimed in 1968....The SRAM-A is one example, but not the only one. It is not sufficient to pull such weapons off the [ready-alert aircraft] force but retain them in the war reserve stockpile in view of the hazards they will present under conditions of great stress should we ever need to generate strategic forces in times of heightened crisis." See Report of the Drell Panel on Nuclear Weapon Safety, p. 32.

113 Ibid., p. 28.

of a missile's propellant, during loading of the missile into a launch tube could result in the
detonation of any (or all) of the missile's warheads." But the Kidder Report also emphasized
that some safety problems with the W76 and W88 warheads identified in the Drell Report still
remained. Because these warheads did not contain IHE or FRPs, both warheads were given a
grade of "C" in their safety evaluation. The report stressed that this does not necessarily mean
that the warheads are unsafe, but that they do not meet modern U.S. safety standards. It did,
however, indicate that the safety of these weapons could possibly be improved by replacing their
warheads with other warheads that did contain IHE and FRPs, such as the W87 warhead or the
W89 SRAMII, and by replacing the third-stage propellant on the Trident missiles with a non-
detonable propellant.

The U.S. arsenal still reportedly contains the W76 and W88 warheads. If the W88
warhead were to be re-designed to contain IHE, it would reportedly require additional, though
moderate, tests. The United States never conducted these tests, however, and the warheads
still appear to lack IHE. In addition, the U.S. arsenal still contains the W62 warhead on the
Minuteman III ICBM. Because the W62 reportedly lacks IHE, FRPs, and ENDS, it received a
"D" in the Kidder Report's safety evaluation. This warhead is scheduled for retirement and
has slowly been removed from the arsenal, but 200 W62 warheads remained on Minuteman III
ICBMs as of June 2000.

<table>
<thead>
<tr>
<th>Table 2.3: Safety and Control Devices on U.S. Nuclear Weapons</th>
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<tbody>
<tr>
<td>Warhead/Weapon</td>
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<tr>
<td>-----------------</td>
</tr>
<tr>
<td>W62 Minuteman III (Mk-12)*</td>
</tr>
<tr>
<td>W76 Trident I / Trident II (Mk-4)</td>
</tr>
<tr>
<td>W78 Minuteman II (Mk-12A)*</td>
</tr>
<tr>
<td>W80-0 Tomahawk SLCM</td>
</tr>
<tr>
<td>W80-1 ALCM/ACM</td>
</tr>
<tr>
<td>W87 MX/Peacekeeper*</td>
</tr>
<tr>
<td>W88 Trident II (Mk-5)</td>
</tr>
<tr>
<td>B61 gravity bomb</td>
</tr>
<tr>
<td>B83 gravity bomb</td>
</tr>
</tbody>
</table>

Sources: Norris and Arkin, "U.S. Nuclear Weapons Safety and Control Features," p. 49; Norris and Arkin,

Requirements, July 26, 1991, p. 5.
116 Ibid., pp. 4-5.
117 Ibid., p. 1.
118 Ibid., p. 4.
Risks of Accidental Launch

During its nuclear history, the United States has had relatively few incidents that involved an accidental release of a nuclear gravity bomb or missile. But such accidents did occur. Most of these accidents involved the accidental release of gravity bombs during the period when a portion of SAC bombers were in constant air alert. In order to help prevent future accidental bomb releases, SAC reportedly adopted safer procedures and developed additional safety devices for bombers. Perhaps the most important change was to take strategic bombers off continual airborne alert in 1968. In addition, after the accidental release over Florence, NC, bomber crews were reportedly ordered to lock in nuclear bombs during flight, which significantly decreased the risk that they could be dropped accidentally. SAC also adopted a bomb release mechanism for strategic aircraft, called the bomber coded switch system (BCSS). The BCSS will not allow an armed nuclear bomb to be dropped until the aircraft commander inserts a proper code to unlock the bomb-bay release system.

Because the United States employs numerous launch controls for its nuclear missiles, the risk of accidental launches is very small. For example, because enabling codes for ICBMs must be transmitted by the national command authority and entered by the launch crews prior to launch, U.S. ICBMs cannot be accidentally launched by pushing the wrong button.

Nevertheless, there have also been some reports of accidental launches of nuclear missiles. On September 19, 1980, during a routine maintenance in a Titan II silo in Damascus, Arkansas, an Air Force repairman accidentally dropped a heavy wrench socket, which fell toward the bottom of the silo. The socket bounced and stuck the missile, causing a leak from a pressurized fuel tank. The missile complex and the surrounding area were immediately evacuated. The fuel vapors within the silo eventually ignited and exploded. The missile burst through silo door (which reportedly weighed 740 tons) and landed about 1000 feet away.

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120 See the list of accidents above, pp. 50–51. Several other reported incidents involved intentional jettisoning of nuclear weapons during serious aircraft malfunctions or prior to airplane crashes. See Hansen, U.S. Nuclear Weapons, p. 228; Kidder, Report to Congress: Assessment of the Safety of U.S. Nuclear Weapons, p. E-2.
124 Plummer and Greenwood, "History of Nuclear Weapon Safety Devices," p. 2; Kidder, Report to Congress:
Although this accident was certainly very serious, it is highly unlikely that the missile would have followed its normal launch trajectory, even if the heavy silo door had not been present.

There have been additional, though less reliable, accounts of accidental launches or near-launches of nuclear missiles. For example, Shaun Gregory reports the following incidents:

- On November 19, 1980, a Titan missile drill reportedly started a missile on a real launch sequence that was prevented only by one of the crew shutting the missile down.\(^\text{125}\)
- In 1984 a computer malfunction at a Minuteman missile silo indicated that the missile was about to launch itself.\(^\text{126}\)
- There were two reported incidents in which “nuclear-tipped anti-aircraft missiles” were launched by accident.\(^\text{127}\)

**Conclusions about Accidental Use**

Overall, the United States has devoted a great deal of research and resources to guaranteeing the safety of its nuclear arsenal. These efforts have largely paid off. By most accounts, the U.S. arsenal is currently the safest in the world. Nevertheless, over the years, the United States made a number of decisions that provided less-than-optimal safety. Some of these decisions led to serious accidents (though never to a full-scale nuclear detonation). As we have seen, the most serious of these accidents arose from the decision to maintain a continual airborne alert for its nuclear bombers and the risks of accident were significantly reduced once the United States eventually took the bombers off airborne alert. But even in its recent history, the United States has chosen to retain warhead designs—and even introduce new warheads—that reportedly do not meet its on (admittedly very rigorous) safety standards. Thus, U.S. nuclear history demonstrates the constant tension between pressures to maintain deterrence or strategic capabilities and those of ensuring safety. We will need to keep this issue in mind when we assess the risks of that emerging NWSs might take.

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\(^\text{126}\) Ibid., p. 97. As evidence for this incident, Gregory cites Cotter, "Peacetime Operations," p. 45, but I was unable to find any reference to this event in Cotter's article.

\(^\text{127}\) Ibid., p. 184.
Unauthorized Use

Throughout its nuclear history, the United States has gone to great lengths to prevent an unauthorized use of its nuclear weapons. Due to the extensive system of physical protection, security procedures (such as the two-person rule), launch controls, and use-control devices, the risks of unauthorized use of U.S. nuclear weapons are currently very small.

In the past these risks were somewhat greater. Before U.S. weapons contained PALs, the U.S. controls relied heavily on security procedures and physical protection. These controls ultimately depended on the reliability of the guard forces and personnel responsible for handling the nuclear weapons. Because the U.S. personnel reliability programs were very good, these controls were probably quite sound, especially when the U.S. arsenal was relatively small. The deployment of large numbers of nuclear weapons in Europe did raise some concern over a weakening of central controls, however. This problem was largely resolved by including PALs on U.S. weapons deployed in NATO countries.

As we have seen, however, naval nuclear weapons lacked sophisticated use-control devices until the late 1990s. While the procedures on naval forces were probably sufficient to prevent a single officer from using the nuclear weapons, critics have argued that the procedures could not prevent a so-called “Hunt for Red October” scenario, where a submarine would be capable of launching its nuclear weapons if the entire crew collaborated. In addition, the use-control procedures on naval nuclear weapons would not prevent the crew from launching their nuclear weapons if they determined that the United States had been attacked (for example, if communications between the central command and the ship were to break down). Nor would they prevent the crew from launching their nuclear weapons if they faced a situation where they had to use their nuclear weapons to save their own lives. It is necessary to stress that these risks were probably quite small (especially because the naval forces were more survivable than other U.S. forces), but they apparently still did exist.128

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128 Feaver argues that while the submarine force would be highly survivable, surface ships are vulnerable to other ships and land-based anti-ship weapons. Moreover, he adds, the systems threatening specific nuclear-armed ships, such as an air base with Backfire bombers, could be in range of navy nuclear missiles. Thus, he concludes, navy commanders may have had at their disposal the very weapons needed to remove the threats they are facing, which is “the canonical recipe” for unauthorized use: a hard-pressed commander deciding to use nuclear weapons on his own authority because he fears the enemy will destroy him before he can get presidential authorization. See Feaver, Guarding the Guardians, p. 50. These risks were largely eliminated, however, with the removal of all nuclear weapons from surface ships in accordance with the 1991–1992 PNIs (see p. 37 above).
Now that all U.S. weapons contain some form of sophisticated use controls, the risks of unauthorized use have been greatly reduced. It would be very difficult for forces possessing nuclear weapons to use them without authorization from higher up in the command chain. Nevertheless, the predelegation of launch authority does increase the risks of unauthorized use. As we have seen, predelegation must involve providing the authenticating and enabling codes to senior military officers for use under specified circumstances. But, as Peter Feaver has noted, this also means that "these same officers could make an illicit launch order look authentic, since there is no one downstream who could distinguish between the correctly predelegated launch order and the unauthorized launch order."129 In addition, predelegation could produce serious difficulties in controlling or terminating a nuclear exchange once it had begun and could increase the possibility of inadvertent war resulting from a warning or assessment error during a crisis.130 Because there is no available information on whether the United States still predelegates launch authority, however, it is impossible to determine whether this risk still pertains today. In any case, since the authority to order a launch has probably been given to only a few reliable officers, the risks of unauthorized use arising from predelegation would probably be fairly small.

One other possible weakness in the U.S. controls against unauthorized use involves nuclear weapons in transit. During transportation, the physical protection of nuclear weapons would be weakest. Because a great number of nuclear weapons were transported during the 1950s and the early 1960s, when U.S. nuclear weapons lacked PALs, there probably was some risk that these weapons could be seized by terrorist groups. The introduction of PALs on weapons deployed in NATO countries helped reduce the risks of unauthorized use if the weapons were seized during transit. But these risks remained for the transportation of naval forces until the late 1990s. And these risks still do not appear to have been eliminated for U.S. ICBMs. If the reports on the use-control devices on U.S. ICBMs are correct, the ICBMs currently lack PALs on the warheads themselves. While the risks of unauthorized launch of deployed ICBMs are minimal due to the PES (which only allows a launch of an ICBM after a specific enabling code is entered), the risks could increase if these weapons were involved in accidents or were stolen during transit.131 Because the United States maintains very good

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129 Ibid.
131 Gregory, The Hidden Cost of Deterrence, p. 34. The danger of an unauthorized individual stealing an ICBM—
physical controls over nuclear weapons in transit, however, the risks of theft of U.S. nuclear weapons during transit are probably quite small. In addition, critical safety devices such as ESDs provide some degree of use control over weapons that lack PALs. Because the weapons can only be detonated under conditions that imitate the flight of the ICBMs, they would still be very difficult to detonate, even in the unlikely event of their theft.132

**Inadvertent Use**

As we have seen, the United States employs a large nuclear arsenal, deployed in a manner that allows for rapid-response, and a use-doctrine that allows for launch on warning. This deployment option increases the survivability of U.S. nuclear forces, but, as a number of scholars have argued, it also significantly increases the risks of inadvertent nuclear war.133 I will not attempt to address this issue in greater detail than these scholars already have. But it is necessary to discuss the main ways that inadvertent use is possible.

**False Alarms**

One of the main potential causes of inadvertent use would be a false alarm generated by the U.S. early-warning systems. As we have seen, the United States relies heavily on a sophisticated system early-warning radars and satellites to detect possible attacks. But the U.S. early-warning sensors reportedly did experience a number of false alarms. The following are several such reported incidents:

- The original U.S. BMEWS had serious defects. Its resolution was poor and its computers were unable to handle heavy traffic or unexpected events. In October 1960, several radars detected a Soviet ballistic missile attack. Although panic ensued, the United States did not respond because redundant sensors did not detect an attack.134

- On October 3, 1979, radar for detecting SLBM attacks picked up a low orbit rocket body that was close to decay and generated a false launch and impact report.135

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132 Stein and Feaver, Assuring Control of Nuclear Weapons, p. 60.
135 Hart and Goldwater, Recent False Alerts, p. 5.
On November 9, 1979, missile crews received warning that a massive nuclear strike from the Soviet Union was on its way. It turned out that a training tape that simulated all the signals of a massive Soviet first strike had mistakenly been loaded into a computer at Cheyenne Mountain. The mistake was discovered only after U.S. leaders also viewed the data from early-warning satellites, which detected no missile launches.136

On June 3, 1980, the SAC command post indicated that two SLBMs had been launched toward the United States. Eighteen seconds later, the display systems showed an increased number of SLBM launches. SAC command post personnel contacted NORAD personnel and the NORAD personnel indicated that they had no indication of launched ICBMs. After a short period, the warning display at SAC indicated that Soviet ICBMs had been launched toward the United States. After another interval, the National Military Command Center (at the Pentagon) received notification that SLBMs were launched. Within a few minutes of the alarm, all of the command posts had reportedly concluded that the data was erroneous because NORAD’s sensors had not detected any launches and because the information received from NORAD did not follow any logical pattern or sequence. In the end it was discovered that the false alarms were caused by a faulty circuit in the communications system that transmitted information from NORAD to U.S. command centers.137

CIA director James Woolsey related a case where the U.S. BMEWS mistook the rising moon for Russian ICBM attack. NORAD experts quickly concluded that this could not be true, because Soviet Premier Nikita Khrushchev was actually in the United States at the time.138

These and similar reported incidents are very troubling. After the false alarm in 1980, however, NORAD did reportedly revise its rules for threat evaluation.139 In addition, as the above incidents also demonstrate, the United States has redundant early-warning systems that can help corroborate or challenge the information from a given set of sensors. In addition, the United States also weighs the information based on human intelligence gathering and assessments of the strategic situation. If other sources of information indicate that an attack is unlikely, U.S. early-warning centers will be much more likely to doubt the data from one set of sensors. For this reason, the risks of inadvertent war are greatest during times of crisis, when experts at U.S. early-warning centers would be more likely to suspect an attack.

137 Hart and Goldwater, Recent False Alerts, pp. 5–7.
139 Blair, Logic of Accidental Nuclear War, p. 194.
Unfortunately, according to open-source reports, several false alarms have also occurred during times of crisis. For example, Scott Sagan has argued that several false warnings occurred during the Cuban missile crisis. In each of the false alarms, the officers involved reportedly believed that war had begun, but in none of the cases were irreversible steps taken.\footnote{Sagan, Limits of Safety, pp. 98–99.}

- On October 25, 1962, a figure was seen climbing the fence at the Duluth Sector Direction Center in Minnesota. Because U.S. personnel had been warned about possible sabotage attempts at command-and-control facilities, the guard forces sounded the sabotage alarm. Unfortunately, the alarm was faulty. Instead of the sabotage alarm sounding, the Klaxon went off, ordering an immediate launch of the aircraft at nearby bases. As the aircraft began to taxi down the runway, the pilots reportedly believed that nuclear war had started. Before the aircraft were able to take off, however, an officer from the command post drove to the runway and signaled the aircraft to stop.\footnote{Ibid., pp. 99–100. As Sagan notes, the supposed saboteur turned out, ironically, to be a bear.}

- On October 28, only minutes before Khrushchev announced his willingness to withdraw missiles from Cuba, radar operators at Moorsetown, NJ detected what appeared to be a missile launch from Cuba against the United States. The radar operators immediately notified the NORAD command center. After verifying the sensor information, NORAD officers relayed the warning information to the SAC Command in Omaha. It was only after the missile was supposed to have reached its target and no detonation was detected that NORAD discovered what the problem was. The error was the result of a training tape mistakenly feeding into the Moorsetown monitors.\footnote{Ibid., pp. 130–131.}

- On October 31, 1962, the radar system at U.S. Air Force control and warning centers in Ontario detected that two unidentified planes had crossed the Mid-Canada Line of NORAD radars. In response, full base defense plans were reportedly implemented and all personnel were notified to expect an impending attack. Because the two aircraft never materialized, however, the two air force bases affected by the warning returned to DEFCON 3 readiness (the heightened alert status maintained throughout most of the Cuban Missile Crisis) after forty minutes.\footnote{Ibid., p. 99.}

Organizational Difficulties and Inadvertent Use

Proliferation pessimists have also argued that serious organizational problems can significantly increase the risks of inadvertent war during crisis situations. During periods of heightened alerts, it becomes much more difficult for states to prevent events from spinning out of control.\footnote{For a detailed analysis of organizational difficulties during crises, see Sagan, "Nuclear Alerts and Crisis Management," pp. 99–139 and Sagan, Limits of Safety.} For example, studies of the Cuban missile crisis have reported several serious
mishaps and organizational difficulties occurred during the crisis that could have possibly triggered a nuclear war. The following are some of these reported incidents:

- On October 26, 1962, as the crisis reached its crescendo, SAC launched a Titan ICBM from Vandenberg AFB in accordance with its predetermined flight-test schedule. Although this missile did not carry a nuclear warhead, the air force had mated the warheads to the other ICBMs at the base and had placed them on alert. If the Soviets had detected the launch and had been aware of the alert status of the other ICBMs at Vandenberg, they could have easily misinterpreted the launch as part of a nuclear attack.\(^{145}\)

- On October 27, an American U-2 reconnaissance plane on a routine air-sampling mission inadvertently strayed into Soviet air space. As Soviet MiG fighters attempted to intercept the plane, U.S. F-102s also flew to escort the plane back to its base. The F-102s were carrying live nuclear anti-aircraft missiles because of the heightened alert. If a dogfight had occurred between the U.S. and Soviet aircraft, the U.S. planes might have detonated nuclear weapons in or near Soviet airspace. Fortunately, the Soviet MiGs failed to intercept the U-2 and the plane was successfully led back into U.S. airspace.\(^{146}\)

During normal, peacetime circumstances, the numerous controls on U.S. weapons and redundant early-warning information make the risks of inadvertent war highly unlikely. But crisis situations increase the likelihood that false alarms would be interpreted as real and operations that would otherwise be interpreted as benign would be misinterpreted as aggressive. Since the end of the Cold War, it has probably become less likely that nuclear crises will arise. Nevertheless, given the recent worsening of U.S.-Russian and U.S.-Chinese relations, one cannot rule out the possibility that nuclear crises will arise in the future. During such crises, the risks of inadvertent nuclear war can increase significantly.


Part II: MPC&A

U.S. Fissile Material Stockpile and Production Facilities

Current Stockpiles

At the end of 1999, the U.S. military fissile material stockpile contained an estimated 100 metric tons of plutonium and 635 metric tons of weapons-grade uranium. It is also estimated to possess 4 to 5 metric tons of separated plutonium from its civil power reactors. The United States has declared 52.5 metric tons of plutonium and 174 metric tons of HEU to be excess of its military purposes. It has made arrangements for the disposition of these materials. The HEU will be down-blended to low enriched uranium (LEU). The blend-down will be carried out by the DOE’s Savannah River Site and Y-12 Plant at Oak Ridge, Tennessee, as well as several private sector companies. Surplus plutonium, on the other hand, will be disposed of in two ways. It will either be burned as mixed oxide (MOX) fuel in domestic commercial reactors or immobilized in ceramic and surrounded by high-level radioactive waste. Both disposition approaches convert the plutonium to the “spent fuel standard” recommended by the National Academy of Sciences.

Fissile Material Production Facilities

During the Manhattan Project, scientists developed two different designs for nuclear weapons. Little Boy was a gun-design weapon using uranium as its nuclear fuel. Fat Man, on the other hand, was an implosion device with a plutonium core. In order to produce fissile materials for these weapons, the United States constructed a small-scale plutonium production reactor and a large uranium enrichment facility at Oak Ridge in 1943. In the same year, the

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150 The “spent fuel standard” requires that weapon-grade plutonium be “converted to forms as inaccessible and unattractive for retrieval and weapons use as the residual plutonium in spent fuel from commercial reactors. In this form, the surplus plutonium cannot be used in nuclear weapons without significant processing.” See “Disposing of Surplus U.S. Plutonium,” Office of Fissile Material Disposition, National Nuclear Security Administration, <http://twilight.saic.com/md/pu_main.htm>.
151 The gaseous diffusion facility for enriching uranium was located at the K-25 site, while the plutonium
United States also constructed a plutonium production facility at the Hanford facility near Richmond, Washington.\(^{12}\)

Between 1947 and 1952, the U.S. Atomic Energy Commission initiated the construction of several new facilities to increase U.S. fissile material production capabilities. These new facilities included three additional gaseous diffusion plants (for enriching uranium) at Hanford; gaseous diffusion plants at Paducah, Kentucky and Portsmouth, Ohio; five additional reactors for producing plutonium at the Hanford facility; and several reactors for producing tritium and plutonium at a new site in Savannah River, South Carolina.\(^{13}\)

The United States stopped production of fissile materials for use in nuclear weapons in 1988. HEU production for nuclear weapons ended in 1964 when the K-25 site at Oak Ridge stopped producing HEU (though the facility was not shut down until 1987).\(^{14}\) Weapons-related plutonium production ended in 1988 when the United States shut down the Hanford and Savannah River facilities. The Hanford Facility was closed due to safety concerns raised by the 1986 Chernobyl accident, while Savannah River was shut down because it was judged that the U.S. stockpile had more than enough fissile materials.\(^{15}\) On July 14, 1992, U.S. President George Bush officially announced a unilateral moratorium on fissile material production for nuclear weapons or other explosive devices.\(^{16}\)
**Weapon Assembly/Disassembly Facilities**

In the early years, Los Alamos National Laboratory constructed nuclear weapons from fissile materials shipped from U.S. fissile material production facilities. In the early 1950s the United States decided that LANL should focus on the development of new weapons designs rather than weapon production. It therefore established the Rocky Flats facility in 1951 to manufacture triggers, or “pits,” from fissile materials, though Los Alamos also retained some pit production capabilities.\(^{157}\) After 1965, Rocky Flats became the only pit production facility in the United States. After fabricating the pits, Rocky Flats then sent them to the Pantex Plant to be incorporated into nuclear weapons.\(^{158}\)

Rocky Flats was shut down in December 1989 due to severe safety and environmental problems. Although the United States briefly considered resuming operations at Rocky Flats in 1990 to produce W88 warhead pits for the Trident II missile, it has never done so.\(^ {159}\) Instead, Rocky Flats has been permanently shut down and U.S. efforts at the facility have focused on environmental clean-up and protection of the large amounts of fissile materials remaining in the facility.

Although President Bush announced in February 1992 that no more W88 warheads would be built, small-scale production of W88 pits was resumed at the TA-55 facility at Los Alamos to replenish pits destroyed in reliability testing.\(^ {160}\)

**Early Fissile Material Controls**

From 1947 to 1954, all special nuclear material (SNM)\(^ {161}\) in the United States was owned by the government and was generally held by the Atomic Energy Commission and its contractors, who ran government-owned or government-controlled plants and laboratories.\(^ {162}\) Early nuclear material controls were based on the military, which played a critical role in the protection of information and nuclear materials with the use of troops, multiple fences, and other.

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\(^ {157}\) Aaron and Berryman, *Rocky Flats Site*.


\(^ {159}\) Ibid., p. 13.


\(^ {161}\) The United States generally refers to fissile materials as “Special Nuclear Materials” (SNM). For specific definitions of the various types of SNM that the United States protects, see Table 4 below.

traditional military security procedures. The U.S. safeguards system was mainly understood to be a matter of economics and fissile materials were controlled primarily because of their intrinsic value, rather than concerns about proliferation or terrorism. As a result, however, there were often serious weaknesses in U.S. fissile material controls. For example, early on, it was perfectly legal to ship kilogram quantities of plutonium through commercial freight, or to store separated plutonium in facilities without 24-hour guard forces.

Increased attention was paid to risks of proliferation and subnational terrorism in the 1960s and 1970s, however, with the introduction of the Atoms for Peace Program and the Nuclear Nonproliferation Treaty, and as incidents of non-nuclear terrorism increased worldwide. In 1966, the AEC established a safeguards advisory panel that raised the issue of safeguards against subnational threats posed by criminals and terrorists. As a result, the AEC increased its efforts to improve physical protection systems for national security nuclear facilities and private-sector power reactors.

In 1974, the Energy Research and Development Administration (ERDA) and the Nuclear Regulatory Agency (NRC) replaced the AEC. The NRC assumed responsibility for the private sector nuclear industry, while ERDA oversaw national security programs and research and development activities. Although ERDA was soon replaced by the Department of Energy (DOE) in 1977, the years that it existed were critical for assessing and improving the safeguards systems in the United States. The ERDA oversaw a number of detailed assessments of the U.S. safeguards system to identify and fix any weaknesses or vulnerabilities. In 1976 a joint ERDA-NRC Task Force on Safeguards produced a report on the current status and future prospects for U.S. MPC&A. While these assessments found that most facilities were generally in compliance, improvements were needed to assure the capability to counter the defined threat levels. The most prevalent issues dealt with controls over access to stored and in-process fissile materials, exit search procedures and security force response capabilities. As part of efforts to improve

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163 Ibid., p. 1.
164 Ibid., p. 4.
166 Desmond et al, “The First 50 Years,” p. 2.
U.S. fissile material controls, ERDA supported research and development activities to provide advanced techniques for modeling, assaying, assessing, and protecting nuclear materials.\textsuperscript{167}

The ERDA was replaced by the Department of Energy (DOE) in 1977. During the first years under DOE direction, research and development activities in safeguards and security flourished. In 1979, the Office of Safeguards and Security was established to develop policy and support safeguards and security applications to assure the nuclear materials inventory at contractor facilities. For physical protection, new concepts in commercially available technologies were applied to provide advanced systems. Safeguards systems also benefited from advances in computing technologies and non-intrusive measurement systems. Security forces personnel were increasingly replaced by automated monitoring and alarm systems, and complex wet chemistry analyses for nuclear material accountability measurements were replaced with automated destructive and nondestructive assay systems.\textsuperscript{168}

In spite of these advances, however, a series of scathing Congressional hearings in the 1980s identified a number of problems with the protection of fissile materials throughout the DOE complex.\textsuperscript{169} In 1982, the House Subcommittee on Oversight and Investigation found that "the DOE was simply not protecting its critical nuclear weapons facilities from a host of real threats," including those of thefts of nuclear materials and sabotage.\textsuperscript{170} In a second set of hearings in 1986, the same subcommittee found that serious problems still remained at some of DOE's nuclear weapons sites. It reported that "the DOE's own internal inspection reports show that plutonium and highly enriched uranium are still highly vulnerable to theft and sabotage at these locations."\textsuperscript{171} The 1986 hearings identified several specific examples to illustrate its findings. For example, inspections revealed that there were no portal monitors to prevent nuclear material from being carried out at some of the exits at the Pantex facility, perhaps the most

\textsuperscript{167} Ibid., p. 5.
\textsuperscript{168} Ibid., p. 7. For a discussion of destructive and nondestructive assay methods, see below, p. 77.
\textsuperscript{169} It is worth asking how "politcized" these hearings were. On the one hand, some of the testimony in the hearings seems to exaggerate some of the vulnerabilities. On the other hand, the investigations did reveal procedural difficulties, missing sensors, and failures in performance tests. These are significant problems that would be difficult to exaggerate.
\textsuperscript{170} Gerry Sikorski, Representative of Minnesota, summarizing the findings of the 1982 Hearings, in \textit{Safeguards at DOE's Nuclear Weapons Facilities}, Hearing before the Subcommittee on Oversight and Investigations of the Committee on Energy and Commerce, House of Representatives, 101\textsuperscript{st} Congress, 1\textsuperscript{st} session, p. 1.
\textsuperscript{171} John D. Dingell, Chairman of the Subcommittee on Oversight and Investigations, Congressional Testimony, in \textit{Safeguards at DOE's Nuclear Weapons Facilities}, Hearing before the Subcommittee on Oversight and Investigations of the Committee on Energy and Commerce, House of Representatives, 101\textsuperscript{st} Congress, 1\textsuperscript{st} session, p. 7.
sensitive facility in the entire U.S. complex.\textsuperscript{172} The Congressional hearings also reported that during a test at the Pantex facility, an insider was able to smuggle a pistol and explosives into the facility to be used several days later in a successful attempt to steal bomb parts containing plutonium.\textsuperscript{173} In addition, the hearings reported that during a test at the Savannah River Site, the guard force reportedly failed to prevent a mock terrorist force from gaining access to the facility and making off with mock plutonium. The guard force was reportedly still shooting at one another 20 minutes after the adversary force had left the facility.\textsuperscript{174}

In a summary of its 1986 findings, the House Subcommittee identified the following general problems with the DOE’s safeguards and security program:

- Lack of credibility in the DOE’s Inspection and Evaluation Program.
- Guard forces are inadequately trained.
- Inadequate protection against insider threat.
- Conflicting state laws over whether guards can use deadly force to prevent thefts of materials.
- Inability to track and recover fissile materials and nuclear weapons in the event that they are stolen from the DOE.
- Reduction of funds for safeguards and security upgrades.\textsuperscript{175}

In additional follow-up Congressional hearings in 1989, the Subcommittee found that the DOE had made some advances in safeguards and securities. It reported that “guard forces at the Hanford Nuclear Reservation, the Savannah River plant, and Oak Ridge are generally well trained and have state-of-the-art weapons and equipment. DOE and its contractors have improved their protection of special nuclear materials and classified documents.” But the Subcommittee also found that serious problems still remained at some facilities. For example, Edward McCallum, the Director of the DOE’s Office of Security Evaluations, reported “serious deficiencies” at Lawrence Livermore National Laboratory, including incidents where Category 1 quantities of SNM\textsuperscript{176} were routinely “left unattended in unalarmed rooms during offshift hours” and incidents where “Category 1 quantities of material were often left, between process steps, with only one person or unattended.”\textsuperscript{177} The Subcommittee concluded that “protecting its nuclear weapons and classified programs is still not a high priority for the Department [of Energy].”\textsuperscript{178}

\begin{thebibliography}{99}
\bibitem{172} Cited in Bunn, “Security for Weapons-Usable Nuclear Material,” p. 16.
\bibitem{173} Dingell, Congressional testimony, in \textit{Safeguards at DOE’s Nuclear Weapons Facilities}, p. 5.
\bibitem{174} Ibid., p. 2.
\bibitem{175} Ibid., pp. 5–6.
\bibitem{176} For the U.S. classification of Category I fissile materials, see Table 4 below.
\bibitem{177} \textit{Safeguards at DOE’s Nuclear Weapons Facilities}, Hearing before the Subcommittee on Oversight and
\end{thebibliography}
In part due to these hearings, funding for the DOE’s Safeguards and Security Program was more than doubled, and hundreds of millions of dollars were spent on a “crash program” to build a host of new security systems, from fences and razor ribbon to high-technology perimeter intrusion detection and assessment systems. More advanced computing systems were also developed to improve materials accountability and to assess potential vulnerabilities in security systems. The DOE also implemented a human reliability program in 1985, which would help reduce potential insider threats by requiring everyone who had access to significant quantities of SNM to undergo extensive medical reviews and drug testing.

Current U.S. MPC&A Systems

A given MPC&A system in the United States is designed to meet the unique requirements of the facility at which it is installed. There are, however, general guidelines with which all MPC&A systems must comply. U.S. MPC&A systems are based on a notion of graded controls, which are designed to provide different levels of protection based on the attractiveness level of the materials present at a given facility. The attractiveness of the material contained in U.S. facilities is determined according to specific criteria. (See Table 2.4 for the graded safeguards categories for given amounts of fissile materials. See Table 2.5 for the recommended MPC&A integration measures for each category of fissile materials.)

U.S. MPC&A systems are generally divided into physical protection and Material Control and Accounting (MC&A) systems. As we have seen in Chapter 1, physical protection systems are intended to deter and defeat attempted attacks on nuclear facilities, while MC&A systems are designed to detect thefts of fissile materials. All aspects of U.S. MPC&A systems are designed to provide “defense in depth,” where there is a degree of redundancy in the systems, so that the failure of one part of the system does not result in the failure of the entire system. The current physical protection and MC&A systems will be discussed separately.

178 Gerry Sikorski, Congressional testimony, in ibid., p. 1.
### Table 2.4: U.S. Graded Safeguards Categories

<table>
<thead>
<tr>
<th>Attractiveness Level</th>
<th>Pu/U-233 Category (quantities in kgs)</th>
<th>Contained U-235 Category (quantities in kgs)</th>
<th>All E Materials Category (IV)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
</tr>
<tr>
<td>Weapons¹</td>
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<tr>
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<tr>
<td>Low-Grade Materials⁴</td>
<td>D</td>
<td>N/A</td>
<td>16</td>
</tr>
<tr>
<td>All Other Materials⁵</td>
<td>E</td>
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</table>

1. Includes assembled weapons and test devices.
2. Includes pits, major components, button ingots, recastable metal, directly convertible metals.
3. Includes carbides, oxides, solutions (≥ 25g/L), nitrates, etc., fuel elements and assemblies, alloys and mixtures, UF₄ or UF₆ (≥50% U-235).
4. Includes solutions (1g to 25g/L) process residues requiring extensive reprocessing, moderately irradiated material, Pu-238 (except waste), UF₄ or UF₆ (≥20%<50% U-235).
5. Includes highly irradiated forms, solutions (<1g/L), uranium containing <20% U-235 (any form, any quantity).


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<table>
<thead>
<tr>
<th>Material Category and Attractiveness Level</th>
<th>Threat Level</th>
<th>Recommended MPC&amp;A Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category I-A</td>
<td>High</td>
<td>Inner Area Within Protected Area</td>
</tr>
<tr>
<td>Category I-B</td>
<td>High</td>
<td>Exterior and Interior Intrusion Detection</td>
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<td>Category II-B</td>
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<td>Rapid Assessment for Intrusion Detection</td>
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<td>Category I-C</td>
<td>High</td>
<td>Substantial Delay Repositories and Vaults</td>
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<td>Vault Storage of Material When Not In Use</td>
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<td></td>
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<td>Authorized Access Control</td>
</tr>
<tr>
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<td></td>
<td>Two-Person Rule or Equivalent Surveillance</td>
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<tr>
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<td></td>
<td>Key and Combination Control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Staffed SNM and Metal Portal Monitoring</td>
</tr>
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<td>Material Measurement and Measurement Control</td>
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<td>Robust Guard Response with Delay Times</td>
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<td>Two-Person Rule or Equivalent Surveillance</td>
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<td>Key and Combination Control</td>
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<td></td>
<td>Staffed SNM and Metal Portal Monitoring, if warranted</td>
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<td>Material Measurement and Measurement Control</td>
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<td>Waste Monitoring</td>
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<tr>
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<td>Acceptable Guard Response within Delay Times</td>
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<td>Category II-D</td>
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<td>Acceptable Guard Response</td>
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<td>Category IV</td>
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<td>Locked Room</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Key Control for Authorized Personnel</td>
</tr>
</tbody>
</table>

Current Physical Protection Systems

Protective Personnel

Protective personnel are employed at all U.S. facilities containing nuclear materials. These personnel include Security Officers and Security Police Officers. These personnel form the core of the "active" protective system, which ensures that the facility operation complies with its license. The qualifications and authority for protective personnel at DOE and DOE-Contractor Personnel are clearly established in official U.S. government regulations. These regulations specify which facilities require protection by Security Officers and which by Security Police Officers, depending on what Category materials are present in the facility. A protective force consisting of Security Police Officers is required at facilities possessing Category I and/or Category II quantities of fissile materials.

Personnel Identification Systems

Entry into a "Restricted Access" area or facility is based on prior authorization and local, live-time validation of the identity of the individual attempting access to the area. Several methods are used to verify personnel identities. One common approach employs a photographic identification card that is checked by a Security Police Officer. In addition, several types of automated access systems have been developed, including systems that require the person seeking access to insert his or her magnetically encoded card and type in a unique personal identification number (PIN), or to identify personal characteristics such as hand geometry or patterns in the retina of the eye.

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184 A "security officer" is defined as "as unarmed individual who is employed for, and charged with, the protection of classified matter or Government Property," while a "security police officer" is defined as "an individual authorized to carry firearms and make arrests who is employed for, and charged with, the protection of DOE assets and who is required to meet the requirements of Title 10, Code of Federal Regulations, Parts 1046, 1047, and 1049, as applicable, and DOE Order 5632.7A." See Coulter et al., "The Structure of Nuclear Material Safeguards Systems," p. II-6.
185 Ibid., pp. II-10–II-11.
186 Ibid., p. II-11.
Barriers

Barriers include physical constructs and administrative procedures, both of which have the same goal: restricting access, movements, and activities in restricted areas and facilities to those persons and activities that have been previously authorized. Common physical barriers to control access include razor-wire fences, reinforced walls and doors, and metal gratings over windows. Administrative barriers are maintained by specific policies and by promulgation of instructions, codes and orders.

Numerous studies have been conducted to assess how well physical barriers provide resistance to forcible assault. These studies have found that a determined and well-equipped adversary can defeat any physical barrier if given enough time. Physical barriers are thus generally regarded as delaying devices intended to prevent an intruder from achieving his or her goal before guard forces can arrive. Because the delays provided by passive barriers such as fences, walls, and doors are surprisingly small, a number of “activated” barriers have been designed to increase delay times. These activated barriers can include some of the following:

- Coils of concertina or barbed wire are suspended near the ceiling in critical rooms and corridors. When an alarm is sounded, the coils are dropped to the floor to impede the intruder’s progress.
- Chemical smoke is dispensed to restrict the intruder’s visibility.
- Aqueous foam is created and released to fill the room containing the intruder or his target, thus inhibiting visibility.
- Sticky foam is dispensed to make it difficult for the intruder to detach the materials or himself from the area. Sticky foam has also been built into some walls and is used to fill any hole created in the walls by explosives.

Detection Devices

The United States currently uses a number of devices to detect unauthorized personnel, materials, and actions in its nuclear facilities. There are two general types of detection devices: intrusion detectors are used to detect unauthorized personnel in a facility, while contraband detectors are used to detect the introduction of unauthorized materials (weapons, cameras, etc.) into a facility or the unauthorized removal of materials (nuclear materials, detection equipment, etc.) from a facility.

Interior and Exterior Intrusion Detectors are either used by protective personnel or are installed within the facility to detect motion. Protective personnel employ various equipment to detect unauthorized personnel in a facility, such as closed-circuit television (CCTV) and night vision devices. Video motion detector (VMD) systems employ television cameras and monitors to observe critical areas. If the VMD systems detect motion in these areas, they trigger an audible alarm and often initiate a video recorder to preserve a picture of the event or motion that caused the alarm.\footnote{Ibid., p. II-14.}

Additional exterior intrusion detectors are strategically located in a cleared area inside the outer security fence of the area being protected. Several detection devices are often used in conjunction to reduce the frequency of unwanted alarms. These detectors include some of the following devices:\footnote{Ibid., pp. II-14–II-16. For an additional discussion of some of these technologies, see the website for the Cooperative Monitoring Center at Sandia National Laboratories, <http://www.cmc.sandia.gov/facts/access/index.htm>.
\footnote{Ibid., p. II-17.}}

- A taut-wire fence, consisting of several tightly strung horizontal wires located at points from near ground level to above normal human height. A small amount of pressure against any of the wires is sufficient to trigger an alarm.
- An electric field fence is used to detect any disturbance in the electric field created by charged wires in the fence.
- Buried-line Intrusion Detectors are similar to electric field fences, but they detect any disturbance in the electric field created by charges wired under the ground.
- Infrared and Microwave Detectors send electromagnetic radiation from a set of transmitters on one post to a set of receivers on another post some distance away. An intruder crossing between the posts would trigger an alarm.
- Seismic detectors are generally buried at specified intervals and produce an alarm if they sense vibrations caused the footsteps of an intruder.

Contraband detectors, on the other hand, are generally located at strategic access points, such as the entrance and exists of a facility. Most of these devices are used in “portal monitors,” through which anyone entering or exiting a facility must pass. They are also generally available in hand-held devices for use by guards. Contraband detectors include explosives detectors, metal detectors, radiation detectors, and X-ray package inspection devices.\footnote{Ibid., p. II-17.}
Communication systems

Communications systems are critical for the success of physical protection systems. In an integrated system, intrusion detector alarms must be received by the Security Force Communications Center, which in turn, must communicate with the facility’s guard forces and possibly with local law-enforcement agencies. The communication system generally relies on phone lines, coaxial cables or fiber optics, and various radio devices. It is critical that facilities have redundant communication systems to prevent the entire communications system from failing if one set of communications fails.\textsuperscript{192}

Current Fissile Material Control and Accounting (MC&A) Systems

Material Accounting

Nuclear materials accountability programs must ensure that all nuclear materials are accounted for and that theft or diversion has not occurred.\textsuperscript{193} It must therefore meet three objectives: to provide assurance that all material quantities are present in the correct amount, to provide timely detection of a material loss, and to estimate the amount of any loss and its location.\textsuperscript{194}

Material Balance Areas

For material control and accounting purposes, nuclear facilities are divided into materials balance areas (MBAs). An MBA is defined such that all movement of material into and out of the area and periodic inventories of materials within the area are measured and recorded through key measurement points (KMPs). KMPs are strategic locations where nuclear material appears in a measurable form that allows determination of the material flow or inventory. The KMPs therefore include input, output, and inventories in MBAs, including discards and storage.\textsuperscript{195}

\textsuperscript{192} Ibid., p. II-19.
Accounting systems

Each facility must have a system that provides for tracking nuclear material inventories, documenting material transactions, issuing periodic reports, and assisting with the detection of unauthorized system access, data falsification, and material gains or losses. An accounting system must begin with proper documentation based on a materials balance equation. The conservation of mass would indicate that:

 Ending Inventory – Beginning Inventory = Input Transfers – Output Transfers

Because there will be some uncertainties in measurement amounts, there must be some specified allowable margins of error on these calculations. The material balance equation (MB) therefore states that:

\[ MB = \text{"beginning inventory"} - \text{"ending inventory"} + \text{"input transfers"} - \text{"output transfers"} \]

The quotation marks around the units indicate that acceptable margins of error in measurements. If the MB is positive, it indicates an apparent loss of materials; if it is negative, it indicates apparent gain of materials. If the MB value exceeds an acceptable range, then immediate action is necessary to discover what caused the imbalance.

The materials balance equation includes all of the material movements across the MBA boundary during the period between two successive inventory determinations. The MBA must be capable of being updated daily or on demand for all nuclear transactions. The material balances are carefully logged into an accounting database and the data is sent to a national database, the Nuclear Materials Management and Safeguards System (NNMSS).

Physical Inventories

In order to verify that the actual amounts of fissile materials in the facility equal the amounts stated in the accounting database, each facility must conduct periodic physical inventories of its fissile materials. In MBAs where the material quantities are in the form of discrete items (such as a storage vault for cans of uranium oxide), material accounting may take the form of item control, by which the identity and integrity of the individual items can be confirmed. In such Item Control Areas (ICAs), the material is confirmed either by verifying that a sealed container or other form of containment has remained intact since the last inventory (e.g.
through a tamper-indicating seal), or by a measurement that verifies that the item has physical characteristics (such as weight or radiation emissions) consistent with the accounting records.\textsuperscript{199}

For facilities that contain bulk materials or non-discrete items such as fluids, the physical inventories must be taken through direct measurement (such as balances or dip-tube manometers), analytical methods applied to samples (such as measuring weight), or by radiation emissions.\textsuperscript{200}

The most straightforward method of determining the quantity of SNM in a well-defined item would be to measure the mass of the object of which the SNM is a part, then to conduct a careful destructive analysis of a small sample to determine the chemical or isotopic composition of the object. But this process is time-consuming, and may be impossible for some types of materials. For this reason, other measurement techniques have been developed. The most effective of these techniques are those that employ nondestructive assay (NDA) of the sample material. NDA techniques obtain mass values for the SNM content of an item, without opening or otherwise disturbing the item or its container.\textsuperscript{201} There are a number of different NDA techniques, including “passive” NDA, which measures spontaneous gamma or neutron emissions, and “active” NDA, which derives is primary information from the interaction of an external radiation source with the sample.\textsuperscript{202}

**Measurement and Measurement Control**

All facilities are also required to implement strict measurement and measurement controls to establish material values and to assure the quality of the data. First, the facilities must establish what measurement methods will be used and when the measurements are to be taken. Second, they must also ensure that the personnel conducting the measurements are properly trained and qualified. Third, they must ensure any sample measured is representative of the bulk of the material that is being tested. And finally, they must ensure that the measurement

\textsuperscript{199} Ibid., p. 1-4.


\textsuperscript{202} For a more extensive discussion of NDA techniques, see ibid., pp. VII-1–VII-41.
equipment is calibrated regularly. The regulations for all these areas must be carefully documented and strictly followed.203

**Material Transfers**

Each facility must also have a program to control and account for internal and external facility transfers of nuclear materials. They must have documented procedures that specify the requirements for authorization, documentation, tracking, verification, and response to abnormal situations that may occur during the transfer of nuclear materials. For example, Category I and II quantities of fissile materials transferred between facilities must be measured independently by the shipper and the receiver to ensure that no materials were stolen or diverted while the materials were in transit. Movements of fissile materials within a facility, such as from one MBA to another, must also be carefully documented and verified, though they only require one transfer check.204

**Material Control Indicators**

The management in each facility is also required to implement a program for assessing any measurement differences (known as material control indicators) to provide assurance that losses or unauthorized removals of nuclear materials are detected. If there is a difference between the material balances calculated by shippers and receivers, or the material balances calculated when material is moved within a facility, the facility must be able determine whether the difference is statistically significant, and if so, what the cause of the difference is. Each facility must also have specific procedures for documenting and reporting any significant differences in material balances.205

**Current Fissile Material Control Systems**

Nuclear control programs must control nuclear materials sufficient to prevent or deter loss or misuse.206 The general requirements for MC&A systems are thoroughly outlined in

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204 Control and Accountability of Nuclear Materials, DOE O 474.1, p. II-12–II-16.

205 Ibid., p. II-18.

206 Ibid., p. 5.
official government documents. These documents divide material control into four functional performance areas: access controls, material surveillance, material containment, and detection and assessment. The requirements in each of these areas depend on the attractiveness level of materials contained in each facility.

**Access Controls**

Each facility containing SNM is required to have a graded program for controlling access to nuclear materials; nuclear materials accountability, inventory, and measurement data; and data generating equipment and other items or equipment where misuse or tampering could compromise the safeguards system. This system would require that only authorized personnel have access to these materials and equipment, and that the equipment contains tamper-indicating devices. 208

**Material Surveillance**

Each facility's management must establish a graded surveillance program for monitoring nuclear materials and detecting unauthorized activities and for reporting material and facility status. Material surveillance may be carried out through some of the following mechanisms: 209

- Intrusion Alarms: These alarms can provide detection capabilities for personnel entering at times when the area should be unoccupied.
- Area Surveillance by Personnel: The two-person rule is a commonly used personnel surveillance method that can be enhanced by supervisor surveillance and monitored closed-circuit television.
- Automated Area Surveillance: Automated surveillance methods could be used that rely on computer control alone or computer control in conjunction with human supervision.
- Shelf Monitors: A shelf monitor continuously measures and reports on a physical characteristic such as weight or radioactive emissions of an item that is placed on a shelf.
- Item Motion Detectors: A transponder-equipped device containing a sensitive accelerometer is placed on top of an item and emits a signal if the item is moved.
- Digital Image Processing: Digital image processing can be used to detect the movement of a single item or large numbers of items. 210
- Automated means through monitoring devices, sensors (such as portal monitors), or other instrumentation to detect anomalies and to report alarm conditions;

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207 See, for example, "Guide for Implementation of DOE 5633-A," Office of Safeguards and Security, Department of Energy, February 1993; and Control and Accountability of Nuclear Materials, DOE 5633.3B.
208 Control and Accountability of Nuclear Materials, DOE 5633.3B, p. III-2.
210 Guidelines for Material Protection, Control and Accounting Upgrades at Russian Facilities, p. 32.
• Visual surveillance either through the two-person rule or monitoring by external personnel to assess SNM material movements or inventory status;
• Through process logs, inventory records, or other information to indicate anomalies and trigger investigations.

**Material Containment**

A critical part of material containment is the division of facilities containing nuclear materials into Protected Areas, Materials Access Areas, and Materials Balance Areas (MBAs). Category I quantities of fissile materials must be used, stored, or processed only within a Materials Access Area that is contained within a protected area. Category II quantities of materials must be used, processed, or stored only within a Protected Area. Both of these categories of materials must be stored in a vault when the materials are not in use.\(^{211}\)

Each facility must also have controls to ensure that nuclear materials are controlled, processed, or stored within a MBA. These controls must ensure that materials are removed from the MBA only via authorized pathways or portals and that they are subject to transfer and verification procedures.\(^{212}\)

**Detection and Assessment**

Each facility must also have the capability to detect and assess the unauthorized removal of nuclear materials. This system should be interfaced with the facility’s physical protection system so that protective forces are notified when unauthorized removals occur. These detection systems should include some of the following elements:\(^ {213}\)

• Tamper-Indicating Devices. These include seals on containers for fissile materials, monitoring equipment, and gauges and other measuring devices.\(^ {214}\)
• Portal monitors. Portal monitors should be placed on exists to the facility and possibly on exits to a given MBA. These monitors should be carefully maintained and performance-checked. Measures should be taken to prevent unauthorized access to portal monitor instrumentation and cabling.

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\(^{211}\) Ibid., p. III-4. See also *Guidelines for Material Protection, Control and Accounting Upgrades at Russian Facilities*, p. 8.

\(^{212}\) *Control and Accountability of Nuclear Materials*, DOE 5633.3B, p. III-5.

\(^{213}\) Ibid., p. III-6.

\(^{214}\) For DOE-wide standards for tamper-indicating devices, see *Safeguards and Security (S&S) Standardization Program*, DOE 5630.17. For a discussion of some of the U.S.-designed tamper-indicating systems, see the website for the Cooperative Monitoring Center at Sandia National Laboratories, <http://www.cmc.sandia.gov/00Technologies/Technologies.htm>.
Waste Monitors. All liquid, solid, and gaseous waste streams leaving an MBA should be monitored to detect thefts or diversion. These monitors could include gamma/neutron radiation detectors.

These detection systems should be tested regularly to ensure that they have not been modified in any unauthorized way.

Integration of the Individual Elements in MPC&A Systems

As previously noted, the entire MPC&A system must be carefully integrated so that all the parts work in conjunction. This requires that the specific objectives of the MPC&A system are identified, the MPC&A system is carefully designed, and the system is extensively performance tested to ensure that the system works as an integrated whole.215

Continuing problems with U.S. MPC&A

Owing to continual improvements in safeguards and security procedures and technologies, U.S. MPC&A programs are probably the most stringent and effective in the world.216 Nevertheless, assessments in the mid- and late-1990s continued to identify problems with U.S. MPC&A. Although many of the problems identified in these assessments were due to historical problems arising from statistical measurements conducted over numerous years, some of them raised ongoing problems with the security systems and accounting procedures at some DOE facilities.

Large Quantities of “Materials Unaccounted For” at U.S. Nuclear Facilities

In 1996, the United States declassified information about the plutonium produced and held at U.S. production facilities.217 In the same report, the United States indicated the “inventory differences” recorded at those sites. These inventory differences, which are defined as the book inventories less the physical inventory, were recorded at the facilities during the years they were in operation. Presumably, annual physical inventories were taken at the sites

and compared with the book inventories.\textsuperscript{218} The inventory differences are usually referred to as "materials unaccounted for," or MUF, in the standard terminology used by the IAEA. The MUF reported at U.S. production facilities were quite large. (See Table 2.6 for the MUF reported at U.S. production facilities as of 1996.)

<table>
<thead>
<tr>
<th>Site</th>
<th>Quantity (in kilograms)\textsuperscript{a}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hanford Reservation</td>
<td>+1,2666.0</td>
</tr>
<tr>
<td>Rocky Flats</td>
<td>+1,191.8</td>
</tr>
<tr>
<td>Savannah River</td>
<td>+232.0</td>
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<tr>
<td>Los Alamos National Laboratory</td>
<td>+47.5</td>
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<td>Lawrence Livermore National Laboratory</td>
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</tr>
<tr>
<td>Argonne National Engineering Laboratory</td>
<td>-3.4</td>
</tr>
<tr>
<td>Idaho National Engineering Laboratory</td>
<td>-5.6</td>
</tr>
<tr>
<td>Other Sites</td>
<td>+16.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>+2,750</strong></td>
</tr>
</tbody>
</table>

\textsuperscript{a} A '+' or '-' denotes that the book inventory respectively exceeds or falls short of the physical inventory.


According to the DOE, the factors that have contributed to the inventory differences include the following:

(1) high measurement uncertainty of plant "holdup"; (2) measurement uncertainties because of the wide variations of the matrix containing the materials; (3) measurement uncertainties due to statistical variations in the measurement itself; (4) in the early years, technology had not been developed to measure the material adequately; (5) measurements for waste are still very uncertain because often small quantities of plutonium or uranium are mixed with a variety of other materials so variable that it is not possible to make accurate calibration sources for measurements; (6) losses from operations, such as accidental spills where accurate measurements were not made before the spill; (7) corrections of human errors in the input of data into accounting systems; and (8) rounding errors.\textsuperscript{219}

As the DOE report indicates, a large amount of the MUF is believed to be due to "holdup," where fissile materials are trapped in pipes, joints, etc., throughout the facilities.

Because most of these facilities are generally well-protected and typically employ systems (such as portal monitors) to detect unauthorized removals of fissile materials, there is a reduced risk that these materials could be stolen. In addition, most of the inventory differences reportedly


\textsuperscript{219} Plutonium: The First Fifty Years, section 10.2; Albright et al., Plutonium and Highly Enriched Uranium, p. 46.
arose from activities in the 1950s, 1960s, and early 1970s, before tighter measurement and accounting requirements were enforced, or even technologically achievable. Nevertheless, with such significant account balances, it would have been nearly impossible to verify whether or not thefts have occurred, particularly during the time that the less advanced measurement and accounting systems were used.

Security Difficulties at Rocky Flats

In the mid-1990s, the security at Rocky Flats came under severe criticism. As noted above, Rocky Flats was shut down in 1989 due to serious environmental and safety concerns. While the facility was not producing new fissile materials in the 1990s, it still contained large amounts of fissile materials, much of which remained in pipes and joints throughout the facility due to "holdup." Thus, even though Rocky Flats was not producing fissile materials, it was critical to maintain strict security at the facility while cleanup operations took place. Unfortunately, the security at this facility was frequently found to be seriously deficient.

In early 1997, David Ridenour, the security chief at Rocky Flats, quit in "disgust," complaining that he could not guarantee security at the site. At the time of Ridenour's resignation, the Secretary of Energy acknowledged that "significant" security problems existed at the site.

Rocky Flats' physical protection systems have had a history of "marginal" or "unsatisfactory" ratings from the DOE and a series of tests over the years have resulted in knowledgeable individuals successfully removing mock plutonium from the facility without authorization or detection. In 1997, shortly before Ridenour resigned from his position, the DOE rated the facility's physical protection as "unsatisfactory." The facility received its first "satisfactory" rating in September 1997, though a DOE report in mid-1997 argued that there was "reason for skepticism" about the improvements because Rocky Flats "has a long history of improving its protective systems only to allow them to degrade once again when priorities shift or external pressures abate." It is therefore probably not surprising that a November 1997 DOE review described security at Rocky Flats again as "less-than-adequate," and indicated that "DOE

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220 Albright et al., Plutonium and Highly Enriched Uranium, p. 47.
221 For the text of Ridenour's resignation letter and an attached report on the difficulties he encountered as security chief at Rocky Flats, see <http://www.whistleblower.org/www/ridenour>.
protective standards were not being met with respect to the protection of special nuclear materials against theft," and pointed to "on again, off again" management attention to physical protection at the facility. In part due to this criticism, significant efforts were made to improve the security at Rocky Flats. DOE officials reportedly believe that most of these problems have now been addressed.

**Office of Oversight Reports in the late 1990s**

The DOE's Office of Independent Oversight and Performance Assurance performed reviews in 1995 and 1998 that found significant problems with the DOE's fissile material assurance programs. In the 1995 report, the Office of Oversight found that no accurate inventories exist for thousands of kilograms of scrap plutonium and HEU in the U.S. complex, and that even though physical protection was generally found to be reliable, "an accurate inventory is necessary for continued assurance against theft of diversion.

The 1998 follow-up report identified "notable progress" in improving the problems identified in 1995, but reported that "many weaknesses in fissile material assurance remain, and the DOE has not yet achieved an acceptable level of confidence in its nuclear material inventory." The 1998 report found that the weaknesses were similar to the problems identified in 1995. The report identified the following general types of weaknesses:

- Significant quantities of fissile materials that have never been measured;
- Inventory values that are not defensible because the measurement techniques were inadequate or not repeatable, or because the inventory value is based on an estimate;
- Materials that have indefensible values because of inadequate or lost records;

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225 The United States General Accounting Office (GAO) also conducted several investigations of the security at DOE facilities. In one report in 1990, the GAO found that at Los Alamos National Laboratory, 78% of the security personnel failed a test of required skills. It reported that of the 54-member guard force, "42 failed to demonstrate adequate skill in using weapons, using a baton, or apprehending a person threatening the facility's security." See *Nuclear Safety: Potential Security Weaknesses at Los Alamos and Other DOE Facilities*, GAO/RCED-91-12, October 11, 1990. These findings are summarized in *Department of Energy: Key Factors Underlying Security Problems at DOE Facilities*, GAO/RCED-99-159, p. 8.


228 Ibid., pp. 11–12.
• Items that cannot be measured because they are inaccessible (e.g., in a high-radiation area);
• Failure to conduct required physical inventories;
• Physical inventories that do not encompass all materials or that do not provide sufficient data to determine whether materials are accounted for;
• Inventory measurements that do not provide assurance that materials have not been diverted;
• Inappropriate inventory practices, such as not updating accounting records after inventory measurements indicate significant differences between the actual amounts of materials and the recorded amounts;
• Incomplete or inappropriate inventory sampling plans;
• Failure to include holdup in accountability records after it has been identified and/or measured.

The serious criticisms in the 1995 and 1998 reports have spurred significant efforts within the DOE to address these problems. In November 2000, the Office of Oversight conducted another follow-up report on the DOE’s MPC&A programs. This report found that the DOE’s MPC&A programs had improved significantly since 1998. The report found that while some corrective actions are still ongoing at several sites, Independent Oversight inspections indicated that most sites now have satisfactory MPC&A programs. The report did note, however, that there are significant remaining weaknesses in MC&A at the Y-12 Plant at Oak Ridge and in accounting programs for irradiated nuclear fuel, including enriched fuel returned from foreign countries.

Part III: Conclusions

Although proliferation optimists point to the United States as one of the primary examples supporting their position, the evidence on this point is far from conclusive. In fact, the experience of the United States should give us more reason for pessimism than optimism about the safety and security consequences resulting from further proliferation. In the following sections, I will first discuss the conclusions that can be drawn from the U.S. case study in the areas of command and control and MPC&A.

230 Ibid., pp. 1, 9–10.
Conclusions about Command and Control

The U.S. case study demonstrates very vividly the level of effort that is required to successfully address what Peter Feaver calls the “always/never dilemma.” NWSs are under simultaneous pressure to ensure that their nuclear weapons “always” work when they need them to, but are “never” used when they do not want them to be used. U.S. strategies for achieving the “always” side have included making technical advances on triggering designs, designing resilient command systems that protect against decapitation, developing large arsenals with the capabilities for rapid response, adopting (at least in the early years) a continual air alert for air forces, predelegating launch authority, adopting a use doctrine that allows for LOW, and developing advanced early-warning systems. These systems have helped ensure that the U.S. arsenal is survivable and resistant to decapitation, but they also make the “never” side of the dilemma extremely difficult to solve.

Through extensive efforts, the United States has made great achievements in reducing the likelihood of accidental, unauthorized, and inadvertent use. As we have seen U.S. weapons include sophisticated safety designs and use-control devices and the U.S. early-warning system contains numerous redundant sensors to minimize false alarms. Nevertheless, this study has identified a number of risky procedures, accidents, risks of unauthorized use, and false alarms that have weakened the U.S. efforts to solve the “never” side of the dilemma.

Because the United States has corrected many (though not all) of these procedures, the U.S. arsenal is now generally considered to be relatively safe. But the U.S. case study should cause us to be very concerned about the further proliferation of nuclear weapons. As we have seen, the greatest risks occurred during the early years of the U.S. nuclear weapons program, before it made significant advances in its weapons designs and use-control devices. But emerging NWSs will have to pass through a developmental stage. While they might be able to avoid some difficulties because many of the necessary technologies are now available on the open market, many necessary technologies are not available or are very expensive. As we have seen, it requires extensive efforts and resources to ensure adequate C³I systems, and it will probably be beyond the capabilities of most emerging NWSs to achieve similar standards that the United States has. Setting aside the technical requirements for producing resilient command-and-control systems, the cost of such systems is extraordinarily high. To put some of these expenses in perspective, a PIDAS for the physical protection of facilities containing Category I
materials costs nearly $1,000 per foot and a typical Cat D PAL device costs an estimated $50,000. It is highly unlikely that emerging NWSs will be able, or willing, to spend limited resources on similar control systems. As a result, emerging NWSs will tend to encounter more severe difficulties in preventing accidental, unauthorized, and inadvertent use than the United States did.

**Conclusions about U.S. MPC&A**

In the first years of the its nuclear program, the United States maintained security through the "threeGs." As the worldwide terrorist threats increased, however, these controls were found to be radically inadequate for protecting against overt and covert (insider) thefts of fissile materials and sabotage of nuclear facilities. Especially during the early years, U.S. government agencies generally did not devote enough serious attention to safeguards and security because their efforts were much more focused on rapid fissile material production.

Over the years, however, the United States did significantly improve its MPC&A. The Department of Energy currently spends approximately $800 million a year on safeguards and security in the DOE nuclear complex and its MPC&A systems are now probably the best in the world. But this progress was typically achieved in fits and starts, often due to scathing investigations by independent agencies and U.S. Congress. This fact alone should cause us to doubt that emerging NWSs will make similar efforts to achieve similar fissile material controls, because it is unlikely that their nuclear programs will allow for similar transparency and oversight.

In addition, we must doubt that emerging NWSs will be able to devote close to the same resources to ensuring adequate MPC&A. As we have seen even after the United States incorporated extensive detection and alarm systems, implemented rigorous requirements for training and security forces, and designed its systems to provide a high level of accounting and control, its MPC&A systems were sometimes still found to have serious deficiencies. This

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233 This figure does not include the additional amounts spent by the Department of Defense for securing nuclear warheads, or the amounts spent by commercial companies handling weapons-usable materials to meet regulations requiring effective security and accounting for these materials. See Bunn, “Measures to Modernize Security and Accounting for Nuclear Materials,” p. 2.
demonstrates the extreme difficulties involved with MPC&A, and we should doubt whether emerging NWSs will be able or willing to design and implement similar MPC&A systems.

**Will emerging NWSs be likely to learn from the U.S. experience?**

Through extensive efforts over numerous years, the United States has managed to develop a number of ways to control its nuclear arsenal and fissile material stockpile. While, in some ways, this case could be interpreted as a qualified case in support of the optimist position, such a conclusion hinges upon whether or not emerging NWSs will learn from the U.S. experience. To a certain degree, we will have to keep this question in mind as we turn to the other cases, but there are nevertheless several reasons to doubt that emerging NWSs will in fact learn from the U.S. experience.

Emerging NWSs will only be able to learn from the U.S. experience if they recognize any problems that the United States had with its nuclear safety and control systems; engage in an open examination of their own programs to identify similar problems; and either avoid adopting systems that lead to such problems, or failing that, implement similar or equivalent solutions to the problems. But there are at least two reasons to doubt that emerging NWSs will do so. First, as Cohen and Frankel argue, the nuclear programs in emerging NWSs will tend to be "opaque," where there is no open debate about the nuclear programs and very little independent oversight of safety and security procedures. As we have seen, these were critical elements in identifying weakness in U.S. safety and security measures and in spurring efforts to correct these weaknesses. If emerging NWSs do not have such open debate or independent oversight, it is doubtful that they will correct any problems in their own programs.

Second, as we have seen from the U.S. case, there is a significant trade-off between developing survivable forces, which require larger forces and dispersed deployments, and maintaining rigorous controls over nuclear weapons. In the early years of its nuclear history, the United States attempted to develop survivable forces and command structures, but in the process adopted procedures and deployments that increased risks of accidents and loss of central control over its nuclear weapons and fissile materials. The United States eventually corrected many of these problems by developing very expensive command-and-control and MPC&A systems. If emerging NWSs attempt to develop survivable forces by increasing their force sizes and

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234 See Avner Cohen and Benjamin Frankel, "Opaque Nuclear Proliferation," *Journal of Strategic Studies*, vol. 13, no. 3 (September 1990), p. 16.
weapons dispersals, they will need to develop systems for controlling their nuclear weapons and fissile materials similar to those employed by the United States. However, the limited resources in emerging NWSs will probably prevent them from being able to afford such systems. Without such controls in place, the nuclear arsenals and fissile material stockpiles in emerging NWSs will be much more vulnerable than those in the United States. In particular, they will become vulnerable during political, social, and economic upheavals. In the next chapter, we will identify more clearly the ways that such upheavals can undermine nuclear controls by examining the effects they have had on the nuclear controls in Russia.
Chapter 3: Russia

Why study Russia?

In early rounds of the debate, Waltz and other optimists pointed to the relative stability that arose between the superpowers during the Cold War as evidence for their position.1 In response, a number of pessimists in the early 1990s argued that the Cold War was not as stable as the optimists would like to think because the superpowers had actually encountered significant command-and-control difficulties over the years, and that the spread of nuclear weapons would be destabilizing because emerging nuclear weapon states (NWSs) would likely experience more severe command-and-control difficulties than the superpowers did.2 Thus, in the early rounds of the debate, both sides acknowledged the importance of Russia, but took opposing positions as to what the case of Russia proved.

The character of the proliferation debate changed, however, with the publication of the articles by David Karl and Jordan Seng.3 In these articles, Karl and Seng maintain that the Russian case is not applicable to the overall question of whether emerging NWSs will have reliable nuclear controls, because the small arsenals and simple command structures in emerging NWSs will allow them to avoid the command-and-control difficulties encountered by the superpowers. As a result of these articles, little more has been said about Russia in the context of the proliferation debate, as scholars turned to examine risks associated with the smaller arsenals of emerging NWSs.4

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4 See, for example, Peter Feaver, “Neooptimists and the Enduring Problem of Nuclear Proliferation,” Security
This chapter demonstrates that the Russian case remains relevant to the proliferation
debate and that it continues to reveal serious difficulties with the optimist position. The Russian
case provides insight into an issue that has not been adequately addressed in the debate, namely
what happens when a NWS undergoes economic, political, or social upheavals. In the last
decade, severe weaknesses have arisen in Russia’s controls over its nuclear arsenal and fissile
material stockpile as a direct result of the domestic upheavals that have plagued Russia since the
fall of the Soviet Union.

During the Cold War, the Soviet Union had massive numbers of nuclear weapons
deployed in Eastern-bloc countries and many of the Soviet Republics. After the fall of the Berlin
Wall in 1989 and the subsequent break-up of the Soviet Union, and many of these weapons
initially remained in the Eastern-bloc countries and several of the newly independent states (NIS)
other than Russia. Recognizing the extreme risk of a loss of control over these weapons,
Moscow, with U.S. assistance, engaged in a massive effort to remove its nuclear weapons from
these countries. All the weapons deployed in Eastern Europe were reportedly returned to Russia
in 1989, but many nuclear weapons remained in the NIS for several years. Although Russia
negotiated and carried out the removal of the nuclear weapons from many of the NIS relatively
easily, it had much more difficulty arranging for the removal of thousands of strategic and
tactical nuclear weapons deployed in Belarus, Ukraine, and Kazakhstan. In 1992, however, the
leaders of these countries signed the Lisbon Protocol, where they agreed to return the nuclear
weapons deployed on their territories. All the tactical weapons were returned to Russia by the
end of 1992, and all the warheads for the strategic weapons were returned by the end of 1996.
But the dangers were not over yet.

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Studies, vol. 6, no. 4 (Summer 1997), pp. 93–99; Mario Carranza, “An Impossible Game: Stable Nuclear
11–24; Clayton Bowen and Daniel Wolvén, “Command and Control Challenges in South Asia,” Nonproliferation
Review, vol. 6, no. 3 (Spring–Summer 1999), pp. 25–35.
Report to Congress, March 1, 1999, p. 4.
4 Ibid., p. 4. Although the vast majority remained in Russia, many strategic nuclear weapons remained in the
former-Soviet Republics of Belarus, Kazakhstan, and Ukraine. Most of the tactical nuclear weapons outside of
Russia reportedly remained in Belarus, Ukraine, and Kazakhstan, but there were also some remaining in Georgia,
Kirghizia, Tajikistan, Turkmenistan, and Uzbekistan.
5 On December 21, 1991, the leaders of the eleven former-Soviet countries signed a treaty that gave Russia the sole
custody over the former-Soviet nuclear weapons.
6 David B Thomson, The START Treaties: Implementation and Status, Center for International Security Affairs
7 Woolf, “Nuclear Weapons in Russia,” p. 4. Although Ukraine returned the last SS-19 ICBMs in 1999 and still has
In the decade following the Soviet collapse, Russia has continued to encounter serious difficulties in maintaining nuclear controls, due to the deterioration of nuclear infrastructures, serious economic constraints, and the weakening of systems for controlling its nuclear weapons and fissile materials. This chapter will examine these weaknesses in great detail.

Part I: Russia’s C3I and the Risks of Accidental, Unauthorized and Inadvertent Use

Russia’s Nuclear Arsenal and Delivery Systems

Russia’s current nuclear arsenal has been estimated to contain approximately 22,500 warheads. Of these warheads, roughly half are believed to be mated to delivery systems. Until the end of the Cold War, the Soviet Union had extremely powerful conventional and nuclear forces. In recent years, however, Russia’s conventional forces have largely collapsed, due to a lack of money to pay soldiers or replace aging equipment. As a result, Russia’s military plans for the next decade have called for an increased reliance on nuclear forces. However, the same economic problems that have hurt Russia’s conventional forces have also hurt Russia’s nuclear forces. Russia’s arsenal is still enormous and extremely powerful, but its strength increasingly lies in its land-based strategic rocket forces, and even those forces are decaying rapidly.

some SS-24 ICBMs, the warheads for all these missiles had been removed in 1996 (ibid., p. 4).


11 A unique feature of Soviet and Russian industry is that all military equipment has finite service life. At the time that any piece of equipment is being produced, the production plant calculates its expected life span, maintenance schedule, and the number of spare parts it will need during its service life. The production plant then delivers all the spare parts along with the original equipment. At the end of the service life, the entire system is scrapped and replaced with a new one (“Interview with Minister of Defense Igor Sergeyev,” Itogi Weekly, October 20, 1998, pp. 22–23). This method worked fairly well during the Soviet era, but it is now causing severe problems for the Russians. They often lack the resources to replace entire systems, and often therefore simply have to decommission old systems or try to extend their service lives without adequate maintenance or replacement parts. To make matters worse, many of Russia’s weapons were produced in other former-Soviet republics, such as Ukraine. Russia is therefore encountering extreme difficulties in extending the operational life of these weapons, because the facilities for producing additional weapons or spare parts are no longer under Russian control.

12 In fact, because of its weakened conventional forces, Russia has changed its “no first use” policy and now reserves the right to use nuclear weapons in response to a conventional weapons attack (OMRI Daily Digest, No.30, February 12, 1997; “Russia May Use Nukes First in Self-Defense,” Reuters, February 11, 1997, p. 1).

Nuclear Arms Control Treaties

INF, IRBM, START I

As discussed in Chapter 2, the United States and Russia negotiated several important arms control treaties in the 1970s and 1980s. These negotiations culminated in SALT I and II, the Intermediate-Range Nuclear Forces (INF) Treaty, and the first Strategic Arms Reduction Treaty (START I). 14

1991–1992 Presidential Nuclear Initiatives (PNIs)

In 1991–1992, the United States and Russia both undertook unilateral initiatives to reduce their tactical nuclear arsenals. 15 In October 1991, Mikhail Gorbachev announced the Tactical Nuclear Weapon Reduction Initiatives, and in January 1992 Boris Yeltsin confirmed and expanded them. Taken together, these initiatives state the following:

- complete elimination of warheads for tactical land-based missiles, artillery shells, and mines;
- elimination of one half of the warheads for anti-ballistic missiles and anti-aircraft missiles; the remaining warheads will be stored at central facilities;
- elimination of one-third of the warheads for surface ships and submarines with the exception of SLBMs; the remaining warheads will be stored at central facilities;
- partial elimination of the warheads for naval aircraft; the remaining warheads will be stored at central facilities;
- elimination of half of the warheads for tactical air force aircraft. 16

In 1996, Russia announced that these measures were scheduled to be completed by the year 2000. Because the PNIs contain no verification guidelines, it is impossible to be certain of the extent to which they have actually been implemented, but some current estimates place the number of tactical weapons in Russia's arsenal at approximately 8,000. 17 Some of these tactical

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14 For a discussion of these treaties, see Chapter 2, p. 36.
15 For a discussion of the PNIs undertaken by the United States to reduce tactical weapons, see Chapter 2, p. 37.
weapons are deployed (mated to delivery vehicles) and some are non-deployed (stored at central storage facilities).\textsuperscript{18}

**START II and START III**

As stated in Chapter 2, although the United States and Russia have both ratified START II, controversy over U.S. plans to create a missile defense system might prevent the treaty's entry into force. It also remains to be seen whether the two countries will be able to negotiate a START III treaty.\textsuperscript{19} Regardless of further progress on START II and START III, however, Russia will almost certainly need to reduce its number of nuclear weapons to significantly below START II levels in the near future because its nuclear forces are deteriorating and will soon need to be removed from service. Russian Defense Minister Sergeyev said that a force of 1,500 weapons would be "safe." Some Russian analysts, like their U.S. counterparts, have argued that 1,500 weapons might be the most that Russia can really sustain.\textsuperscript{20} First Deputy Prime Minister Yuri Maslyukov stated on October 6, 1998 that in the near future the most Russia could hope for is several hundred nuclear charges.\textsuperscript{21}

\textsuperscript{18} These "non-deployed" tactical weapons are not slated for destruction. See Sokov, "Russia: Status and Trends in Tactical Weapon Deployment," p. 1.

\textsuperscript{19} For a discussion of START II and III, see Chapter 2, p. 37


<table>
<thead>
<tr>
<th>Type (NATO Designation)</th>
<th>Range (km)/Warheads x Yield</th>
<th>No. of Weapons (START I MOU/Current)</th>
<th>Total No. of Weapons (START I MOU/Current)</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td><strong>Intercontinental Ballistic Missiles (ICBMs)</strong></td>
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<tr>
<td>SS-18 (Satan)</td>
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<td>204/180</td>
<td>2,040/1,800</td>
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<td></td>
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<td>Kartaly: 46</td>
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<td></td>
<td>Domboroskiiy: 52</td>
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<td>SS-19 (Stiletto)</td>
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<td>170/150</td>
<td>1,020/900</td>
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<td>SS-24 M1/M2 (Scalpel)</td>
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<td>45/46 M1: 36 M2: 10</td>
<td>430/460</td>
<td>Bershet: 15</td>
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<td>Krasnoyarsk: 9</td>
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<td></td>
<td>Tatishchevo: 10</td>
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<tr>
<td>SS-25 (Sickle)</td>
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<td>430/360</td>
<td>234/360</td>
<td>Irkutsk: 36</td>
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<td>Drovyanaya: 18</td>
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<td>SS-27 (Topol-M)</td>
<td>10,000–10,500 km 1x550kt</td>
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<td>SS-N-18 M1 (Stingray)</td>
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<td>224/192</td>
<td>672/576</td>
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<td>Yagel'naya: 4</td>
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<td>Delta III Subs</td>
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<td>SS-N-20 (Sturgeon)</td>
<td>8,300</td>
<td>120/80</td>
<td>1,200/800</td>
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<td>10 x 200 kt (MIRV)</td>
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<td>Typhoon Subs</td>
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<td>SS-N-23 (Skiff)</td>
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<td>448/448</td>
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<td>Delta IV Subs</td>
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<td>SS-1 SCUD B</td>
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<tr>
<td>985kg/ dual capable</td>
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<td>Delta III Subs</td>
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<tr>
<td>SS-21 (Scrab)</td>
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<td>Nerpich'ya: 6</td>
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<td>480 kg/ dual capable</td>
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<td>SS-X-26</td>
<td>400</td>
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Table 3.1 continued on following page
### Sea-launched Cruise Missiles (SLCM) (Tactical)

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<th>Type</th>
<th>Range</th>
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<tr>
<td>SS-N-3B (Sepal)</td>
<td>460</td>
<td>1 x 350 kt (dual capable)</td>
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<td>SS-N-9 (Siren)</td>
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<tr>
<td>SS-N-12 (Sandbox)</td>
<td>550</td>
<td>1 x 350 kt (dual-capable)</td>
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<td>SS-N-19 (Shipwreck)</td>
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<td>1 x 500 kt (dual capable)</td>
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<td>SS-N-21 (Sampson)</td>
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<tr>
<td>SS-N-22 (Sunburn)</td>
<td>110</td>
<td>1 x 200 kt (dual capable)</td>
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### Surface-to-Air Missiles (SAM) (Tactical)

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<th>Type</th>
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</thead>
<tbody>
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<td>SA-N-6 (Grumble)</td>
<td>100 Possibly nuclear</td>
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### Anti-Submarine Weapons (ASW) (Tactical)

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<td>55</td>
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<td>SS-N-15 (Starfish)</td>
<td>45</td>
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<tr>
<td>SS-N-16 (Stallion)</td>
<td>100</td>
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### Russia's C³I System

Although Russia’s initial command-and-control system relied on the physical separation of nuclear warheads from their delivery vehicles, this system was fundamentally changed in the latter part of the 1960s when the Soviets became concerned about the survivability of their nuclear forces and command structure, given the increasing accuracy and rapid flight times of U.S. missiles. Because of these concerns, the Soviets adopted a planning requirement that...

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22 Until recently, there was very little unclassified information on Russian C³I. But several recent publications have allowed much more insight into the Russian C³I system, particularly the works of Bruce Blair and Amy Woolf, and a Russian document: Paul Podvig, Oleg Bukharin, Timur Kadyshhev, Eugene Miasnikov, Igor Sutiagin, Maxim Tarasenko, and Boris Zhelesov, *Russia's Strategic Nuclear Weapons* (Moscow: IzdAT, 1998).
allowed for the option of launch-on-warning (LOW) and placed their missiles on a permanent alert.23

LOW

Under this system, the Soviets would be able to detect an incoming nuclear attack and launch a massive retaliation before the incoming U.S. missiles could reach their targets.24 LOW would ensure both that the Soviet intercontinental ballistic missile (ICBM) arsenal would not be destroyed by a U.S. strike, and that the Soviet nuclear force would not be “decapitated,” that is, that its command, control, and communications (C3) would not be destroyed or so completely disrupted that they would be unable to launch a retaliatory strike. According to Bruce Blair, these were legitimate concerns, because during most of the Cold War, a first-strike by the United States might in fact have been capable of destroying a large number of Soviet ICBMs or decapitating the Soviet C3 system.25 LOW was therefore implemented (at least in part) to help ensure a credible retaliatory capability.26 Thus, although the capability for LOW introduces inherent dangers (such as an increased chance of inadvertent nuclear war), it was implemented to reduce very real risks and help maintain credible deterrence.

In order to carry out LOW, the Soviets needed both to establish a reliable early-warning system that could detect an incoming nuclear attack and to develop the ability to launch their ICBMs in less than 15 minutes after the warning was received.

Russia’s Ballistic Missile Early-Warning System (BMEWS)

The Soviets began research on its ballistic missile early-warning system (BMEWS) in the late 1950s as part of its Anti-Ballistic Missile (ABM) System, which was designed to protect critical command-and-control centers in Moscow from a ballistic missile attack. Eventually, however, BMEWS became a critical part of the Soviet launch-on-warning capability. Plans for a

23 Podvig et al., Russia’s Strategic Nuclear Weapons, p. 52.
24 The Soviets chose to allow for the option of launch on warning; this does not mean that they would necessarily have responded to all attacks with such retaliations.
26 Many U.S. analysts believed the Soviet policy was also implemented to allow for a first strike, which would also benefit from a C3 system that gave them the ability to launch their nuclear weapons extremely rapidly.
comprehensive BMEW system were approved in 1972. This comprehensive system would include long-range radar, over-the-horizon radar, and satellite-based BMEWS.

Long-Range Radar

The Soviet Union’s domestic BMEW system officially began operation on February 15, 1971, when the first two surveillance radars, located near Murmansk and Skrunda, were put on alert status.27 Both of these posts used Dnestr-M long-range radar, which could detect approaching ballistic missiles at distances of up to 5,000 km.28 During the next several years, the Soviets built a number of Dnestr-M and higher-voltage, upgraded Dnepr long-range surveillance radars (both of these radars are usually called “hen houses” by U.S. intelligence experts). In the mid-1970s, the Soviet Union began constructing a new type of long-range radar called Daryal radars (usually called “Large Phased-Array Radars” or “LPARs” by U.S. intelligence experts). By the mid-1980s, they had completed several LPARs and had begun construction on several more.

After the breakup of the Soviet Union, however, most of these BMEWS remained outside of Russia, causing a major disruption in the BMEW system. In addition, the construction of many of the LPARs has never been completed and many of the remaining early warning radar facilities (especially the Hen Houses) will soon need to be retired because they are reaching the end of their service lives. Russia will probably have extreme difficulty building many more of these radar stations, given its current economic shortages. In 2000, Russia did commission an additional early-warning station in Baranovichi, Belarus, which will help fill the gap left by the closing and recent disassembly of the radar station located in Skrunda, Latvia.29 But Russia’s early-warning radar system is still far from comprehensive and it will probably continue to deteriorate as the aging radar stations reach the ends of their service lives and are retired. (See Table 3.2 for the current status of Russia’s early-warning radars, Figure 3.1 for the locations and reconnaissance zones for Hen House radars, and Figure 3.2 for the locations and reconnaissance zones for LPARs.30)

27 Podvig et al., Russia’s Strategic Nuclear Weapons, p. 409.
28 Ibid., p. 409.
29 “Belarus Early Warning System to be Tested,” Interfax, August 2, 1999 in FTS19990802001187 (August 2, 1999).
30 Figure 1 and Figure 2 are based on Podvig et al., pp. 411, 413; Department of Defense, Soviet Military Power, 1987, U.S. Government Printing Office, 1987, pp. 48–49.
Table 6.2: Russia’s Ballistic Missile Early-Warning Radars

<table>
<thead>
<tr>
<th>Radiotechnical Center</th>
<th>Radars</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Murmansk</td>
<td>Hen House</td>
<td>Reaching end of service life.</td>
</tr>
<tr>
<td>Olenegorsk</td>
<td>LPAR</td>
<td>Experimental receiver model.</td>
</tr>
<tr>
<td>Mishelevka</td>
<td>2 Hen Houses</td>
<td>Reaching end of service lives.</td>
</tr>
<tr>
<td></td>
<td>LPAR</td>
<td></td>
</tr>
<tr>
<td>Pechora</td>
<td>LPAR</td>
<td></td>
</tr>
<tr>
<td>Krasnoyarsk</td>
<td>LPAR</td>
<td>Radar eliminated.</td>
</tr>
<tr>
<td>Nikolayev, Ukraine</td>
<td>Hen House</td>
<td>Negotiations over control never completed. Reaching end</td>
</tr>
<tr>
<td></td>
<td></td>
<td>of service life.</td>
</tr>
<tr>
<td>Mukachevo, Ukraine</td>
<td>Hen House</td>
<td>Negotiations over control never completed. Reaching end</td>
</tr>
<tr>
<td></td>
<td></td>
<td>of service life.</td>
</tr>
<tr>
<td>Sary Shagan, Kazakhstan</td>
<td>2 Hen Houses</td>
<td>Reaching end of service lives.</td>
</tr>
<tr>
<td></td>
<td>LPAR</td>
<td>Radar never incorporated into BMEW system.</td>
</tr>
<tr>
<td>Baranovichi, Belarus</td>
<td>LPAR</td>
<td>Commissioned in 2000.</td>
</tr>
</tbody>
</table>


Over-the-Horizon Radars

In an attempt to increase the advance warning times for their early-warning radars, the Soviets attempted to install a system of over-the-horizon radars, which reflect short-wave radio waves off the ionosphere (a part of the Earth’s outer atmosphere that reflects radio waves of a certain wavelength). An over-the-horizon radar would therefore detect a missile launch sooner than the regular long-range radars would. The first Russian project using over-the-horizon radar to detect ballistic missiles began in the late 1940s. Because of technical difficulties, Russia suspended this program until the end of the 1950s. By the mid-1970s, Russia had built two over-the-horizon radars, located near Pripyat and near Bolshaya Kartel in Khabarovsk Kray (although the Bolshaya Kartel radar was not put on alert status until 1982). These radars remained on alert status until 1990, when they were shut down and partially dismantled.

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31 Podvig et al., *Russia’s Strategic Nuclear Weapons*, p. 414.
32 Ibid., p. 415.
Figure 1: Locations and Reconnaissance Zones of "Hen House" Radars

Legend

- Never incorporated into Russian BMCL system
- Currently functioning, but reaching end of service life
- Radar dismantled in 1998
Figure 2: Locations and Reconnaissance Zones of LPARs
Satellite-Based BMEWS

Research into satellite-based early-warning systems began in the late 1960s and continued through much of the 1970s. Actual deployment of this early-warning system began in 1977. The initial system, called Launch Detection System-1 (LDS-1) in the United States, employs satellites traveling in overlapping high elliptical orbits that detect the infrared radiation from a ballistic missile launch against the background of space. This system became operational in 1978 (after six satellites were in orbit) and it was placed on alert status in 1982. Although at its peak the Soviet system consisted of nine satellites with overlapping orbits, it requires a minimum of four satellites for continuous surveillance of the United States and Western Europe.33

In 1984 the Soviet Union began launching geostationary satellites for a second orbital BMEW system, called Launch-Detection System-2 (LDS-2) in the United States.34 Between 1984 and 1998, the Soviets and Russians launched nine geostationary satellites, but a number of these satellites proved to have defects that caused them to fail soon after they were launched. In September 1997, Russia had only two functioning geostationary satellites remaining. Russia launched another geostationary satellite on April 29, 1998, but it reportedly failed the following July.35 Russia’s final two functioning geostationary satellites are believed to have failed in 1998.36

33 Ibid., pp. 415-416.
34 The Soviets actually launched one experimental geostationary satellite in 1975 but had suspended further launches until 1984 (ibid., p. 415). For the definition of geostationary satellites, see p. 42, n. 43 above.
**Table 3.3: Russia’s Early Warning Satellites (Launched after 1986)**

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Launch Date</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kosmos-2232</td>
<td>January 26, 1993</td>
<td>Working, as of 1997.*</td>
</tr>
<tr>
<td>Kosmos-2241</td>
<td>April 6, 1993</td>
<td>Working, as of 1997.*</td>
</tr>
<tr>
<td>Kosmos-2261</td>
<td>August 10, 1993</td>
<td>Working, as of 1997.*</td>
</tr>
<tr>
<td>Kosmos-2386</td>
<td>August 5, 1994</td>
<td>Working, as of 1997.*</td>
</tr>
<tr>
<td>Kosmos-2312</td>
<td>May 24, 1995</td>
<td>Working, as of 1997.*</td>
</tr>
<tr>
<td>Kosmos-2340</td>
<td>April 9, 1997</td>
<td>Working, as of 1997.*</td>
</tr>
<tr>
<td>Kosmos-2342</td>
<td>May 14, 1997</td>
<td>Working, as of 1997.*</td>
</tr>
<tr>
<td>Kosmos-2350</td>
<td>Possibly launched in 1999?</td>
<td>Working?</td>
</tr>
</tbody>
</table>

**Geostationary Satellites**

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Launch Date</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kosmos-2224</td>
<td>December 17, 1992</td>
<td>Was working, at Prognoz-2 as of September 1997; Maneuvers stopped before May 1998.</td>
</tr>
<tr>
<td>Kosmos-2345</td>
<td>August 14, 1997</td>
<td>Was working, at Prognoz-1 as of September 1997; Maneuvers stopped in late 1997.</td>
</tr>
</tbody>
</table>

*Some number of these satellites had failed by 1999. Russia reportedly has only three working high-elliptical satellites.

**Sources:** Podvig et al., *Russia’s Strategic Nuclear Weapons*, pp. 416–417; Bogatrev, “Russian Antimissile Defense Cracks,” p. 2; Wooll, “Nuclear Weapons in Russia,” p. 5; “Russia’s Strategic Forces Stumble,” p. 4.

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**The Current Status of Russia’s BMES**

This BMES system has seriously deteriorated since the collapse of the Soviet Union. As noted, many Soviet early-warning radar stations are no longer under Russian control and many of the remaining radars are reaching the ends of their service lives. In addition, Russia’s satellite systems have been failing rapidly. In 1997, Russia had seven functioning high-elliptical satellites. By 1999, this number had reportedly dropped to three, causing the satellite coverage to be blind for at least seven hours each day and possibly much more.\(^{37}\) Although the two

remaining geostationary satellites helped fill some of the gaps in Russia's satellite surveillance, even these satellites appear to have stopped working.\(^\text{38}\)

The deterioration of the Russian BMEW system has created great concern that Russia would be unable to identify and correctly characterize missile and rocket launches.\(^\text{39}\) To help avoid problems that might arise from the deteriorating system, in the June 2000 summit meeting, Presidents Bill Clinton and Vladimir Putin agreed to establish a permanent joint early-warning center to share information about nuclear launches. As of June 2001, however, little progress had been made.\(^\text{40}\) The proposed plan has become mired in details—the Russians have reportedly said that Russian law requires Americans to pay taxes on equipment brought into the country and to assume liability for construction, while the U.S. side did not want to set a precedent that would affect larger aid programs.\(^\text{41}\)

**Russia's Command-and-Control Structure: Launch Procedures and Use-Control Devices**

Russia's main nuclear-weapon command-and-control system is called the Kazbek system. In this system, the links in the chain of command for transmission of an order to launch nuclear weapons are completely disengaged under normal conditions. It would generally require a preliminary command from the President and Defense Minister to engage these communication links. While these communication links are disengaged, it is impossible for a launch command to be transmitted accidentally or by an unauthorized party.\(^\text{42}\) In addition, both civilian and

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\(^{38}\) Johnathan McDowell, Harvard astrophysicist, interview by author, October 24, 2000. See also Bogatrev, "Russian Antimissile Defense Cracks," p. 2. Another troubling incident occurred on May 11, 2001 when a fire ravaged an important ground relay to Russian satellites, interrupting or breaking communications with four military satellites. At the time, Russian officials refused to comment on what the satellites' specific function was, but later reports indicated that they were in fact part of Russia's early-warning satellite system. The reports differed on how long the communication links were interrupted. Some reports indicated that the communication links were interrupted for several hours, some said that they were interrupted for 24 hours, and some say that the links were down for four days. See "Fire in Russia Space Center," *New York Times*, May 11, 2001; "Russian Satellite Links Cut: Relay Station Fire Inturrupts Contact," *Reuters*, reported in *Washington Post*, May 11, 2001, p. A36; Philipp C. Bleek, "Fire Shuts Down Russian Early-Warning System," *Arms Control Today*, June 2001.


military authorities are able to override unauthorized efforts to launch missiles and sever communications with sites receiving unauthorized information.43

In the event of detection of a nuclear attack by satellite sensors or early-warning radar, Russia's early-warning center would send a warning to the headquarters of the Defense Minister, the General Staff, and the Strategic Rocket Forces, as well as a special warning to the President, Defense Minister, and Chief of the General Staff through their nuclear suitcases (or Chegets).44 The President, Defense Minister, the Chief of the General Staff, the nuclear commanders-in-chief, and the head of the early-warning center would then confer on special communication lines to assess what the threat is. If they received secondary verification of an incoming attack and judged that the technical warning was not in error, then the President and Defense Minister would transmit a "preliminary command" via their Chegets, which would engage the communication links necessary for subsequent launch commands.45

If this detection of a nuclear attack took place during a nuclear crisis (or if the Russians were launching a first strike), the leaders would have already retired to reinforced command centers, from which they could issue the preliminary command directly.46 In these cases, the nuclear suitcases would be superfluous.47

While it generally requires the command from the President and Minister of Defense to engage these communication links, Podvig et al. note that "some steps required to raise the level of readiness could also be taken on the orders from the General Staff."48

If the leaders decided to give an actual launch command, they would relay the command to the General Staff and strategic force commanders.49 The General Staff would then disseminate the appropriate orders and launch codes to the branches of the Armed Forces, which in turn would relay the launch command and enabling codes necessary for launching the nuclear weapons. Or, alternatively, the General Staff could deliver the launch orders for strategic weapons directly to the launch platforms, which (after a several minute delay) would automatically launch the weapons from silos or truck launchers.50

44 Blair, Global Zero Alert, p. 46.
45 Podvig et al., Russia's Strategic Nuclear Weapons, p. 58.
46 Ibid., p. 57.
47 Blair, Logic of Accidental Nuclear War, p. 73.
48 Podvig et al., Russia's Strategic Nuclear Weapons, p. 57.
49 Blair, Global Zero Alert, p. 48.
50 Ibid., pp. 50–51. See also Podvig et al., Russia's Strategic Nuclear Weapons, p. 167.
Some recent assessments of Russia’s command-and-control structure suggest that the President, Defense Minister, and the Chief of the General Staff are not actually necessary for the launch of Russian nuclear weapons. If these assessments are correct, the authorization codes conveyed by the suitcases are merely proof of the approval of the Cheget-holders, while the General Staff controls the actual codes required for the launch of Russian strategic missiles.  

ICBMs

The level of alert status and the corresponding combat-readiness of Russian ICBMs have changed fundamentally over the years. In 1960, three levels of alert status were instituted in Russia’s Strategic Rocket Forces (RVSN). Under normal circumstances, Russian missiles were kept in a state of “permanent readiness.” In this state, the missiles were stored in silos without the nose sections mated. (In the case of the R-12 missile, the gyros were also not attached.) During a “red alert,” the intermediate alert status, the nose section and the gyros (on the R-12) were attached to each missile. In a “full alert,” the highest alert status, the missiles were fueled and aimed. It reportedly took several hours to prepare the missiles for launch under this system.  

When the Soviets adopted a launch-on-warning policy, however, they had to reduce dramatically the launch times for their missiles. They therefore changed the alert status of their missile forces to a “permanent red-alert,” where the missiles were stored fully fueled, with their re-entry vehicles (including the warhead) mated. In this new system, the ICBMs can be launched in less than 15 minutes. The General Staff can disseminate the launch commands by one of two methods: by delivering the authorization codes to launch crews (who then carry out the launch), or by delivering the launch orders directly to the launch platforms, which (after a several minute delay) automatically launch the weapons from silos or truck launchers.  

Russian ICBMs and ICBM silos have sophisticated use-control devices. First, it appears that Russian missile warhead detonation systems are deactivated during normal circumstances.

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52 Podvig et al., Russia’s Strategic Nuclear Weapons, p. 165.

53 Ibid., p. 166.

54 Blair, Global Zero Alert, pp. 50–51; Podvig et al., Russia’s Strategic Nuclear Weapons, p. 167.
and require a separate command to activate them. This command cannot be given before the communication links are engaged by the preliminary command. It is possible that an authorization code must be entered in order to activate the warhead detonation systems.

If the General Staff chose to have the launch crews launch the ICBMs, they would first send a message to the Strategic Rocket Forces headquarters containing the command to unlock specific launchers and the unlocking codes for those launchers. The launch crews would then enter the authorization codes and launch the missiles. Only those launchers designated for immediate launch need be unlocked. They automatically lock again if they are not launched in a short period of time. In addition, Russian missile silos are equipped with sensors that would detect an unlawful entry or an attempt to defeat the locks on the missiles. In either of these cases, the launch mechanism for the ICBM would be automatically disabled.

**SLBMs**

According to one account of early Soviet launch procedures for SLBMs, targeting information was contained in a General Staff package that was opened after the submarine received the order to institute red alert status. The launch codes were contained in an additional package that was kept in the personal safe of the submarine’s commanding officer. These codes were only entered into the missiles after the commanding officer and his senior watch officer both verified the authenticity of the launch order. In the early 1970s, the launch codes were no longer contained on the submarine itself, but were transmitted to the submarine along with the order to launch the missiles. This system is still used by Russia today.

On early Russian submarines, the pre-launch procedures were mostly conducted manually and took about an hour to perform. On modern submarines, these procedures are automated and take two or three minutes. SLBMs can be launched either from submarines on

55 Podvig et al., *Russia’s Strategic Nuclear Weapons*, p. 57.
56 Ibid., p. 167.
60Communications with Russian submarines on patrol are ensured by simultaneous transmission on a number of different frequencies, including at least two very-long-wave (VLW) frequencies, five short-wave (SW) frequencies, and five satellite frequencies (ibid., pp. 272–273).
61 Ibid., p. 275.
62 Ibid.
patrol or from submarines in port.\textsuperscript{63} It is possible that the SLBMs on submarines in port are connected to the Kazbek system and can be launched automatically in the same way ICBMs can.

According to a 1996 report by the \textit{Washington Times}, the use-control devices on Russian submarines were quite weak at that time. The report states that "some submarine crews probably have an autonomous launch capability for tactical nuclear weapons and might have the ability to employ SLBMs as well."\textsuperscript{64} If this information is true, then the Russian central command would have been unable to stop a rogue submarine attack.\textsuperscript{65} However, Russian command and control over its submarine-launched nuclear weapons has apparently been improved since 1996. Russian submarines apparently no longer have the ability to launch nuclear weapons without receiving enabling information from the General Staff.\textsuperscript{66}

\textit{ALCM and Gravity Bombs}

There are three levels of alert for Russia’s strategic air forces. During peacetime (alert condition 1), nuclear weapons are stored away from the bombers in facilities near the airfields.\textsuperscript{67} In the second level of readiness (alert condition 2), the planes would be prepared for takeoff and nuclear munitions would probably be loaded on them.\textsuperscript{68} Under red alert (alert condition 1), the planes would be fully prepared for takeoff and might even have their engines running.\textsuperscript{69}

Bomber crews would probably receive a preliminary command to use nuclear weapons (along with the command to load the weapons on the bombers) and a final command to use the weapon after takeoff. The bombers might also be equipped with locks to prevent an accidental or unauthorized missile launch or bomb release. The unlocking codes for these locks would probably be transmitted along with the final command to use the nuclear weapons. If an actual order to use the nuclear weapons were given, the planes would fly to designated launch points

\footnotesize
\begin{itemize}
  \item \textsuperscript{63} ibid., p. 55.
  \item \textsuperscript{64} Gertz, "Russian Renegades Pose Nuke Danger," p. A1.
  \item \textsuperscript{65} Amy Woolf, on the other hand, argues in 1996 that submarine crews had to receive authorization codes from the national command authority before they could launch their SLBMs (Woolf, "Nuclear Weapons in the Former Soviet Union," p. 8).
  \item \textsuperscript{66} Kathleen Bailey, testimony before the U.S. Senate Armed Services Committee, Subcommittee on Strategic Forces, March 31, 1998, <http://www.senate.gov/~armed_services/statemnt/980331kb.htm>, p. 7. Bailey appears to be referring only to SLBMs, rather than tactical nuclear weapons (particularly because Russian naval vehicles are no longer supposed to carry tactical nuclear weapons).
  \item \textsuperscript{67} These storage facilities are guarded by special military units (Woolf, "Nuclear Weapons in the Former Soviet Union," p. 8).
  \item \textsuperscript{68} As an additional precaution, the authorization to move the weapons would be transmitted through a different chain of command than that used for the order to increase the alert status of the bombers themselves (Ibid., p. 8).
  \item \textsuperscript{69} Podvig et al., \textit{Russia's Strategic Nuclear Weapons}, p. 354.
\end{itemize}
and launch their cruise missiles. The bombers are equipped with a system of locks that prevent their missiles from being fired from anywhere except these designated launch points.\textsuperscript{70}

Although the nuclear-capable bombers contain relatively sophisticated use-control devices, it has been reported that the bombs contain relatively crude locks and that the cruise missiles have no adequate controls at all.\textsuperscript{71} Blair refers to Russian sources, which state that “a captured cruise missile armed with a nuclear payload could be readily launched from a variety of planes and would produce a nuclear detonation.”\textsuperscript{72} It is possible, however, that the weapons for Soviet heavy bombers may contain a mechanical lock or an electronic PAL that must be unlocked with codes transmitted by the General Staff and the national command authority before they can be armed and employed by the bomber crews.\textsuperscript{73}

**Tactical Weapons**

As we have seen, Russia promised to destroy all land-based tactical nuclear weapons—including land-based tactical ballistic missiles, artillery shells, and mines—in the 1991–1992 PNIs. In these same initiatives, Russia also committed to removing tactical nuclear weapons from its Naval forces.\textsuperscript{74} If Russia is complying with these commitments, then there will not be any launch procedures for these weapons because they will already be in long-term storage. If the Russians are not complying with the initiatives or if they decide to re-deploy tactical nuclear weapons, it is not clear what their launch procedures would be.

According to the PNIs, the only tactical nuclear weapons that will be deployed are the gravity bombs and short-range cruise missiles for tactical bombers.\textsuperscript{75} These weapons are contained in storage facilities located near the bombers and are guarded by special military units.\textsuperscript{76} In the event of a nuclear crisis, guards must receive special authorization to unlock and move the weapons to the bombers.\textsuperscript{77} Although it is not clear what use-control devices or launch procedures exist for tactical bombers, they are probably similar to those for strategic bombers.\textsuperscript{78}

\textsuperscript{70} Ibid., p. 354; See also Blair, *Logic of Accidental Nuclear War*, p. 17.
\textsuperscript{71} Blair, *Global Zero Alert for Nuclear Forces*, p. 17.
\textsuperscript{72} Ibid., p. 17, n32.
\textsuperscript{73} Woolf, “Nuclear Weapons in the Former Soviet Union,” p. 8.
\textsuperscript{74} See p. 93 above.
\textsuperscript{75} See p. 93 above.
\textsuperscript{76} Woolf, “Nuclear Weapons in the Former Soviet Union,” p. 8.
\textsuperscript{77} Ibid., p. 8.
\textsuperscript{78} See p. 108 above.
A number of experts have expressed concern over whether Russia has adequate command and control of its tactical nuclear weapons. Because most of Russia's tactical nuclear weapons are contained in storage facilities, the security of these weapons is only as good as the level of security of the storage facilities. It is not clear that Russia has been willing or able to provide the necessary resources for the secure storage of its nuclear weapons.  

To make matters worse, it is not clear that Russia's tactical nuclear weapons are equipped with very sophisticated use-control devices. Some land-based tactical nuclear weapons may be equipped with PALs, but the quality of the PALs may vary among different types of tactical weapons and some older weapons may not have them at all.  

The use-control devices for sea-based tactical nuclear weapons are reportedly even worse than those for land-based ones. According to Woolf, "some of these weapons, such as the nuclear-armed torpedoes on attack submarines, may not contain PALs. Instead, the Soviet Union had instituted organizational procedures to complicate the unauthorized launch of tactical nuclear weapons by a ship or submarine captain." If the sea-based tactical nuclear weapons have been removed from the naval vessels, however, then there would be no organizational procedures to maintain any command and control over these weapons.  

Contrary to all these negative reports about Russian protection of its tactical nuclear weapons, General Eugene Habiger, head of the U.S. Strategic Command at the time, gave a very positive assessment of Russian controls. He argued that Russia does an excellent job protecting all of its nuclear weapons, including the tactical ones.  

**Perimeter System**  

In addition to the Kazbek system, Russia has a second, reserve command-and-control system known as the Perimeter system. This newer battle management system became operational in 1985. Designed to reduce the risk of decapitation, the Perimeter system uses rockets to transmit launch orders directly to strategic missile launchers. These rockets are launched by the central command station (or a reserve command station). The rockets fly over

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80 Ibid., p. 8.  
81 Ibid., p. 8.  
missile positions, continuously transmitting the launch command and authorizing codes. It appears that ICBMs can be launched either by launch crews, who enter the transmitted codes, or automatically, by remote transmission of the launch codes to the missile launchers themselves. The signals transmitted by the rockets could also be received directly by submarines and bombers (or transmitted to them by relay stations).

In order to launch Russian ICBMs with the Perimeter system, one must both be able to launch the communications rockets and know the ICBM launch codes that will be transmitted by the Perimeter rockets. It is possible that if the President and the Minister of Defense work together, they have the ability to launch Russia’s ICBMs using the Perimeter system. There is some question whether or not the General Staff can also launch Russia’s ICBMs using the Perimeter system. According to Blair, the General Staff does have this ability, although Podvig et al. do not make a similar suggestion. Judging by most of Russia’s controls, it is likely that the communication rockets for the Perimeter system require authorization codes to be entered before they can be launched. It is not clear, however, whether the President and Minister of Defense have sole control over these codes, or whether the General Staff also has access to them.

"Dead Hand"

It appears that the Perimeter system was also designed to allow for the semi-automatic launch of Russia’s strategic nuclear weapons. This capability has been called the “Dead Hand” because it would allow the leadership to ensure the launch of Russia’s weapons even if it were destroyed by a nuclear attack. If the Russian President expected an attack or if an attack was actually detected, he could order the activation of the Perimeter system and possibly distribute

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84 Podvig et al., *Russia’s Strategic Nuclear Weapons*, p. 61.
85 Ibid., p. 61. See also Blair, *Global Zero Alert for Nuclear Forces*, p. 53.
86 Podvig et al., *Russia’s Strategic Nuclear Weapons*, p. 61.
87 Podvig et al. argue that the President and the Minister of Defense have to order the transmission of the command to launch Russia’s weapons. They say Russia’s command-and-control system was designed so that the military could prevent a situation where the supreme commander (the president) alone could make the decision to deliver a first strike (Podvig et al., *Russia’s Strategic Nuclear Weapons*, p. 59). This implies, however, that if the President and the Minister of Defense worked together, they could make the decision to deliver a first strike.
89 There might, for example, be some procedures that give the General Staff the ability and the authority to launch the Perimeter rockets if it has become clear that the President and Minister of Defense have been killed by an incoming nuclear attack (Podvig et al., *Russia’s Strategic Nuclear Weapons*, p. 60).
the launch codes to an underground command node outside Moscow.90 If the command node did not receive an order to stop the combat algorithm within a given period of time, the command rockets would launch automatically.91 The staff of the combat node would then transmit the launch command and the launch codes via the command rockets.92

There have been some reports that the communication rockets for the Perimeter system can only be launched if special seismic sensors detect the detonation of nuclear weapons on Russian territory.93 If this is the case, then the Perimeter system could not be used to launch a first strike. Podvig et al., however, do not appear to indicate that the detection of nuclear detonations is necessary for the launch of the communication rockets.94

Podvig et al. argue that the “Dead Hand” was never actually deployed because it was determined to be too dangerous. However, there does seem to be a fair amount of evidence that this system was or could still be deployed.95

The Deterioration of Russia’s Command-and-Control System

A number of recent reports have claimed that Russia’s command-and-control system is collapsing due to the combined effects of aging systems and severe economic hardship. The articles refer to a number of incidents to illustrate their case:

- The Kazbek system has been in continual use since 1983, even though it was only intended to last 10 years. Due to a lack of funding for maintenance and modernization, the system is reportedly falling into disrepair.96
- On a number of occasions in the last several years, critical communication links to nuclear submarines were cut off and the operations at some nuclear weapons centers were severely disrupted when thieves tried to “mine” communications cables for scrap metal.97
- The service lives have expired for a great number of Russia’s nuclear weapons. Although Russia has attempted to extend the service lives for a number of the weapons, it

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90 Blair, Global Zero Alert for Nuclear Forces, p. 52.
91 Podvig et al., Russia’s Strategic Nuclear Weapons, p. 61.
92 Blair, Global Zero Alert for Nuclear Forces, p. 52. The staff of the command node probably does not have the discretionary authority to decide whether or not to transmit the launch codes (Ibid., p. 52).
93 Ibid., p. 52. See also Steven J. Zaloga, “Russia’s Doomsday Machine,” Jane’s Intelligence Review, February, 1996, p. 55.
94 Podvig et al., Russia’s Strategic Nuclear Weapons, p. 61.
is not clear how much Russia can extend them without compromising the safety and reliability of the weapons.⁹⁸

● Local utility managers have repeatedly shut off the power to various nuclear weapons installations after the military authorities there failed to pay their electric bills. Power was shut off at Gadzhiyev naval base and weapons storage facilities on September 21, 1995; at the military shipyard Sevmorput on September 26, 1995; and at bases for Air Defense and Strategic Rocket Forces in the Khabarovsk territory on July 20, 1999. And on June 27, 2000, troops from the Strategic Rocket Forces base in Sibirskiy were forced to stage a commando raid on a neighboring power company after it threatened to shut off its electricity.⁹⁹

● The equipment that controls nuclear weapons reportedly malfunctions frequently, and critical electronic devices and computers sometimes switch to a combat mode for no apparent reason.¹⁰⁰

Although this list is quite troubling, Russia’s command-and-control technologies and procedures have been fairly resilient so far. What is particularly unnerving about this list is that it indicates trends that could undermine Russia’s command and control in the future.¹⁰¹

The Risks of Accidental Use

The use of a weapon would be considered accidental if “everyone is surprised” by its use.¹⁰² The following are the risks of accidental use of Russian nuclear weapons

Accidental Detonation

Russia has instituted several technical and procedural means of protecting against the accidental detonation of its nuclear weapons. First, according to Bruce Blair, some Soviet warheads or delivery systems were equipped with environmental sensing devices (ESDs), which ensured that the warheads would only detonate if specific environmental conditions were met. He alleges that electronic devices on a Soviet strategic missile warhead monitor the missile’s acceleration, the surrounding barometric pressure, and the missile’s deceleration to determine

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¹⁰¹ For a similar assessment, see Woolf and Wilson, “Russia’s Nuclear Forces,” pp. 24–28.
whether to arm itself for detonation.  Although Blair only specifies that the ESDs were implemented on Soviet strategic missile warheads, they have presumably been carried over into some Russian warhead designs as well.

A second way that the Russians protect against accidental detonation is by removing some components necessary for detonation from their warheads during transportation and perhaps even while they are deployed in the field. As part of the Cooperative Threat Reduction Program, the United States helped research and fund improvements on the railway transportation system for Russian nuclear weapons. In order to help the United States design improvements to railcars designated for transporting Russian nuclear weapons, the Russians allowed the United States to ship one of their railcars to Sandia National Laboratory. Inside the railcar was a locked compartment where the components necessary for warhead detonation would be stored. There is some indication that these components are kept separate from warheads while the nuclear weapons are deployed in the field. Podvig et al. perhaps refer to the same safety procedures when they state that the warhead detonation systems on Russia’s ICBMs are disengaged during normal circumstances. While these detonation systems are disengaged, it would be much harder for an accidental detonation to occur. Because these detonation systems would probably be engaged if Russia’s nuclear forces were put on a higher state of alert, however, the chance of accidental detonation would correspondingly increase during a nuclear crisis.

Finally, the Russians reduce the risk of accidental detonation by trying to design their warheads, as the United States does, to be “one-point safe.” Such warhead designs greatly reduce the chance that a significant nuclear yield would result if the high explosives in a warhead were accidentally ignited. The Russians initially claimed that their regulations on the

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103 Blair, *Logic of Accidental Nuclear War*, p. 107. Blair notes that ESDs also help control against unauthorized use, because these environmental conditions are almost impossible to imitate from the ground. For a more detailed discussion of the role of ESDs in protecting against unauthorized use, see Peter Stein and Peter Feaver, *Assuring Control of Nuclear Weapons: The Evolution of Permissive Action Links*, CSIA Occasional Paper No. 2 (University Press of America, 1987), p. 23.
104 The railway system allowed for the transportation of warheads from their deployment locations to warhead disassembly facilities.
107 Podvig et al., *Russia’s Strategic Nuclear Weapons*, p. 57.
108 Because some of Russia’s nuclear weapons can be launched automatically, without the participation of launch crews (see p. 106 above), either these weapons do not have the components removed from their warheads, or the components can be re-installed automatically.
109 The United States definition of one-point safety is “when the weapon’s high explosive is detonated at any single point, the probability of producing a nuclear yield greater than four pounds TNT equivalent is less than one in a
probability of an accidental warhead detonation under abnormal conditions are more stringent than U.S. regulations. After they were questioned about these regulations, however, it became clear that Russian calculations include not only the probability of a nuclear yield given the accidental ignition of high explosives, but also the probability of such an accident occurring in the first place. Because U.S. requirements for “one-point safety” only consider the probability of a significant nuclear yield after an accidental detonation of the insensitive high explosives has occurred, they are probably more stringent than Russian regulations. It is impossible to tell for certain, however, because the Russians have been unwilling to reveal either their specific regulations or the specific method of analyzing compliance with these regulations.

There is some evidence, however, that the Russians do not generally use insensitive high explosives (IHE) in their nuclear weapons. During a meeting conducted under an international agreement in 1997, John Dallman (a high explosives expert at Los Alamos National Laboratory) and other members of the U.S. team got the impression that IHE only has limited use in the Russian nuclear program, based on personal conversations and the topics the Russians discussed in their papers. Under some accident circumstances, there could be a greater likelihood that the conventional explosives in a nuclear weapon will detonate if it contains HE instead of IHE. An accidental detonation of conventional explosives could disperse plutonium in a deadly aerosol or even cause a significant nuclear yield if the nuclear weapons are not properly one-point safe. Given that Russian regulations for one-point safety appear to be less rigorous than U.S. regulations, the risks of a nuclear yield during an accident might be higher than many experts would like them to be.

It is also possible that some risks of accidental detonation could arise from Russia’s aging weapons. A U.S. document on the DOE Stockpile Stewardship Program reports that as stockpiled weapons age, a number of physical changes can take place that can affect nuclear weapon safety, performance, and reliability. These changes include:

110 According to U.S. experts involved in the CTR Program, interviews by author.
111 John Dallman, interview with author, August 20, 1999.
113 Los Alamos National Laboratory Nuclear Weapons Program: Focus on the Stockpile, November 1998, LALP-
Degradation of organic high explosives;
- Cracks and voids developing in or among components;
- Aging of plutonium, producing a buildup of impurities; and
- Changing of material characteristics, with subsequent dimensional changes (creep).

Although this document focuses specifically on U.S. nuclear weapons, one could presume that similar changes would occur in aging Russian warheads, and that the safety, performance, and reliability of Russian warheads could be affected in similar ways. Aging can produce changes in high explosives that could have unknown effects on detonation properties. Changing detonation properties in turn can affect both the likelihood of HE detonation and the likelihood of a nuclear yield in the event of an accident. The United States does not currently know of any effects of aging that could increase the likelihood of HE detonation, but this is a relatively new field and much more research is necessary.

Risks of Accidental Launch

Accidental ICBM Launch

Russia has instituted a number of technical and procedural controls that greatly reduce the chance of an accidental ICBM launch. First, the communication links for the Kazbek system are disconnected under normal circumstances. A command to launch the missiles cannot be transmitted accidentally during these times. Second, because the warhead detonation systems on Russian ICBMs appear to be disengaged during normal circumstances, if an ICBM were accidentally launched during these times, it would probably not result in a nuclear yield. Third, because Russia's ICBMs require authorization codes to be entered before they can be launched, no one can accidentally launch an ICBM by pushing the wrong button.

In May 1994, U.S. President Bill Clinton and Russian President Boris Yeltsin agreed to stop aiming strategic missiles at each other. Although this detargeting agreement was highly touted by the Clinton administration, it is likely that it had only a marginal effect in reducing the nuclear danger. Although the Russians claim that it would take over 10 minutes to retarget the missiles, some extremely reliable U.S. sources—including James Woolsey, former Director of

97-134, p. 15.
914 Ibid.
915 Podvig et al., Russia's Strategic Nuclear Weapons, p. 57. Of course, even an accidental launch of an unarmed ICBM could cause another state with an early-warning system and a launch-on-warning policy to retaliate.
Central Intelligence—argue that the retargeting of Russian ICBMs would take less than a minute. If this is true, then the detargeting agreement would therefore not dramatically reduce dangers of an inadvertent launch that accompany the quick decision-making necessary for launch-on-warning military postures.

However, the detargeting agreement could reduce the catastrophic consequences of an accidental launch if the missile defaults were set to launch a missile harmlessly toward the ocean if a technical error or mechanical failure caused the missile to be accidentally launched. But there are conflicting accounts of whether the default settings on Russian missiles have been reprogrammed in this way. According to Blair, in the event of an accidental or unauthorized launch, Russian ICBMs would revert to their old Cold War targets. On the other hand, James Woolsey argues that the detargeting would render the Russian missiles harmless in these circumstances.

One thing is certain, however: if an accidental launch were to occur, Russia probably would not be able to destroy the missile mid-flight. According to Colonel General Vladimir Yakovlev, the former Commander of the Russian Strategic Rocket Forces, although Russian test missiles are fitted with a self-destruct mechanism, the actual combat missiles are not. If the

118 For a discussion of risks of inadvertent launches of Russian weapons, see p. 128 below.
120 Woolsey, “Threats to United States National Security,” p. 27.
121 The self-destruct mechanism on a test missile would cause the missile to explode if it veers too far from its original trajectory or if its third booster rocket does not ignite properly (Yakovlev, quoted in Moscow Interfax, “Russian Forces to Get Topol-M Rockets Despite Launch Mishap,” October 26, 1998, in FTS199810260000378). This statement differs from Bruce Blair’s 1991 congressional testimony that Russia’s deployed ICBMs also have a self-destruct mechanism that would activate if the missiles veered from their original launch trajectory. Blair does point out, however, that an accidentally launched missile would be most likely to follow its normal trajectory and would not self-destruct even if it had this mechanism (Bruce Blair, Congressional Testimony, Command and Control of Soviet Nuclear Weapons: Dangers and Opportunities Arising from the August Revolution, Hearings before the Subcommittee on European Affairs of the Committee on Foreign Relations, U.S. Senate, September 21, 1991). See also Bruce Blair, “Break-up of the U.S.S.R.: Whither Nuclear Control?,” Transnational Law and Contemporary Problems, vol. 2, no. 2 (Fall 1992), pp. 534–535. A self-destruct mechanism should be distinguished
defaults on Russia’s missiles are still set for their old Cold War targets, there would be no way to stop a missile from hitting the United States in the unlikely event of an accidental launch.  

Nevertheless, as we have seen, there are in fact a number of procedures and controls for Russian ICBMs that would protect against accidental launches. For this reason, the most careful and reliable assessments of Russia’s strategic nuclear systems have determined that the risk of an accidental ICBM launch is currently quite small.

**Accidental Gravity Bomb/Cruise Missile Release**

The risks of accidental bomb releases or air-launched cruise missile (ALCM) launches appear low for a number of reasons. First, during normal, peacetime circumstances, nuclear bombs and cruise missiles are stored in guarded storage areas away from the bombers. If this is the case, then the risk of an accidental release of a gravity bomb or ALCM launch during peacetime is quite small. Second, in the highest level of alert, bombers are sitting on runways with their nuclear weapons loaded and perhaps with their engines running. Even in the event of hostilities, Russian nuclear bomber forces would not fly combat patrol missions. Third, the bombers are equipped with locks that prevent a release of their weapons unless the pilot follows a specific flight pattern and enters a specific unlocking code that would probably be transmitted along with the final command to use the nuclear weapons.

There is, however, one trend that seems rather troubling. Russia’s recent economic crisis has hit the Air Force quite hard, and the Air Force has had to cut back the amount of training that pilots receive. In 1998, the Russian air force only received 15 to 40% of its normal flight training. In order to ensure that these nuclear missions are safely conducted, the pilots of...
nuclear bombers would need to be carefully trained in all the safety procedures for flying military missions with nuclear weapons. But it is not clear that Russian pilots are receiving this kind of training. Unless Russian nuclear bomber pilots have received significantly more training than the average pilots, they could make serious mistakes—including crashing their planes (which could cause a dispersal of fissile material or even cause a nuclear yield). As long as the procedures for nuclear bombers remain the same, however, the risk of an accidental nuclear bomb release or nuclear ALCM launch will remain quite small.128

Accidental Submarine-Launched Ballistic Missile (SLBM) Launch

In general, there is not a major risk associated with accidental launches of SLBMs. There is a high degree of centralization on Russian SSBNs, so any procedures will probably have a high degree of supervision. In addition, there appear to be use-control devices on Russian SLBMs that would prevent their launch except by the direct command of the Russian authorities.

Although it is possible to fire the SLBMs from submarines in port,129 it is not exactly clear how these would be launched. If these weapons are launched in the same way as when the submarine is at sea, then the same kinds of procedures and use-control technologies would help prevent an accidental launch. If the SLBMs on submarines in port can be launched automatically by the Kazbek system, they are also probably subject to the same (low) risks of accidental launch as Russia’s ICBMs.130

The Russian Navy is encountering the same problems with poorly trained forces as the Air Force is encountering. Because the Navy lacks the necessary funds to keep its submarines running, naval officers are not receiving the amount of training they used to receive. To make matters worse, morale is extremely low among the naval forces because of sporadic payment of wages and deteriorating social conditions. This forces many officers to leave the navy in search of better financial opportunities. The increased turnover rates further reduce the average training of the naval officers. As a result of the decreased training of naval officers and the reduced

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128 It is possible that these procedures could change if tensions with the United States or another country increased dramatically or if there were a breakdown in the Russian military structure.
129 See p. 107 above.
130 See p. 116 above.
routine maintenance and repairs of the ships, the safety levels on both decommissioned and operating naval ships are being severely compromised.\(^{131}\)

It is very difficult to say what effect the poorly trained submarine crews will have on the risk of accidental launches. Because there does seem to be a high degree of centralization on the SSBNs, it is not clear whether the submarine commanders will be as poorly trained as the general submarine crews. Probably the greatest risk associated with poor training of submarine crews would be accidentally sinking the submarine and causing an environmental disaster.\(^{132}\)

**Accidental Use of Land-Based and Sea-Based Tactical Nuclear Weapons**

In the 1991 PNIs, President Gorbachev committed to destroying tactical land-based ballistic missiles, artillery shells, and mines, and to removing all tactical nuclear weapons from Russia’s Naval forces.\(^{133}\) If Russia has complied with these initiatives, then the risk of accidental use of Russia’s tactical nuclear weapons is currently quite small. Because there are no verification guidelines for this treaty, however, it is impossible to know to what degree Russia has complied with them.\(^{134}\) But even while these weapons were deployed, the risk of an accidental use of these weapons was relatively small during peacetime circumstances, because the standard procedure for these weapons from the Soviet era to the present was to store the warheads separately from their delivery systems.\(^{135}\) While the weapons are stored this way, the chance of accidental launch remains small. It is not clear, however, whether there are any controls to prevent accidental launch once the warheads are mated to the delivery vehicles.

**Conclusions about the Risks of Accidental Use**

Overall, Russia’s current controls have kept the risks of accidental launches of its nuclear weapons quite small. It is not clear, however, that Russia’s controls will remain as secure as they have been. Severe economic and political hardships in recent years have caused several...
dangerous trends that could erode Russia's controls and thereby increase the chance of accidental use.\textsuperscript{136}

First, Russian troops are poorly trained and might be less able to handle nuclear weapons safely.\textsuperscript{137} So far, Russia's current procedures and use-control devices have probably prevented the poor training of its troops from significantly increasing the risk of accidental use, but it is difficult to foresee how this will affect risks in the longer term.

Second, Russian warheads, missiles, and command-and-control equipment are all aging, and it is not clear that Russia is willing or able to spend the necessary funds to renew these systems. Most indications seem to be that the Russian system would fail safely, but it is very difficult to predict what the effect of aging missiles and warheads will be. In all likelihood, it will simply make them inoperative, but aging circuitry or aging high explosives could increase the risk of an accidental missile launch or warhead detonation.\textsuperscript{138}

\textbf{The Risks of Unauthorized Use}

The unauthorized use of a nuclear weapon "refers to the deliberate use by people who have access to the weapon, but who lack authority legitimately to order its use."\textsuperscript{139} For example, if a state had inadequate controls over its nuclear weapons, a crazed soldier or fanatic general could independently decide to use the nuclear weapons, even though the state's central authorities had not ordered the use. Or, alternatively, a proliferating country or terrorist group could steal a nuclear weapon and use the weapon on its own.

Most of Russia's nuclear weapons systems have some form of protection against unauthorized use, and some of the controls are very good. According to Robert Walpole, U.S. National Intelligence Officer for Strategic and Nuclear Programs, an unauthorized launch of one of Russia's ICBMs is "highly unlikely."\textsuperscript{140} While the 1998 Rumsfeld Commission agrees with Walpole, it notes that this situation could change dramatically if Russia's political situation were

\textsuperscript{136} Blair, Feiveson, and von Hippel, "Hair-Trigger Alert," pp. 74–76.
\textsuperscript{137} Ibid., p. 74–75. See also "Low Morale, Outdated Arms Reported in Russian Army," \textit{Interfax}, November 11, 1998 in FBIS-UMA-98-315; Nilsen et al., "The Russian Northern Fleet," section 1.3.2.
\textsuperscript{138} For example, aging circuitry was determined to be the cause of an accidental launch of a South Korean surface-to-air missile on December 4, 1998. The missile reportedly self-detoned mid-flight, injuring a dozen civilians and damaging scores of cars and houses. See "More on Accidental Firing of ROK Missile," \textit{The Korea Times}, December 5, 1998, in FBIS-EAS-98-338, p. 1.
to continue to deteriorate. Nevertheless, it is important to note that these conclusions relate only to Russia’s ICBMs. The risk of the unauthorized use of other nuclear weapons in Russia’s arsenal, such as ALCMs or tactical weapons, could be significantly greater because these weapons often lack sophisticated use-control devices.

Several scenarios of unauthorized use have been discussed in the literature on Russia’s nuclear arsenal, including a breakdown of control at the top of the command chain, a revolt by a regional leader or military commander, and the theft of a nuclear weapon. I will discuss each of these scenarios in turn.

**Loss of Control at the Apex of Power**

In this scenario, there is a loss of legitimate control over nuclear weapons at the very top of the chain of command. The most likely scenario of such a loss of control would be if the General Staff attempts to seize control over the nuclear weapons. A great deal depends on whether or not the General Staff has the technical ability to launch the nuclear weapons without the participation of the Cheget-holders.

For the General Staff to use the Kazbek system, they would need to activate the communication links necessary for issuing a launch command, then transmit the authorizing codes necessary for launching the nuclear weapons. Although the General Staff might be able to activate the communication links on its own, there is still some question whether the General Staff controls the authorizing codes. If they do (as many open-source assessments indicate), then they probably could seize control of Russia’s nuclear weapons. But even if they do not, it might be possible for them to override the Kazbek system. In all likelihood, however, this would require a fair amount of time and probably could only be carried out during a large-scale, organized coup d’etat. Of course, such a coup d’etat did occur in 1991, and it is generally agreed that there was a serious weakening of Russia’s nuclear controls.

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144 Podvig et al., *Russia’s Strategic Nuclear Weapons*, p. 57.
145 A CIA document on Russian command and control reportedly says that the safeguards on all Russian nuclear devices can be defeated, “probably within weeks or days depending on the weapon involved” (quoted in Jim Wolf, “CIA Rates ‘Low’ the Risk of Unauthorized Use of Russian Nuclear Weapons,” *Reuters*, October 23, 1996, p. A06).
In the August 1991 coup, communist hard-liners at the very highest governmental levels attempted to oust President Mikhail Gorbachev and restore the old order. The coup plotters included the Defense Minister and possibly the Chief of the General Staff, the two Cheget-holders other than the President. During the coup attempt, Gorbachev was arrested and his nuclear suitcase was seized. Russia's nuclear controls were thus severely strained during the coup, but most assessments indicate that they were not completely compromised. One of the main reasons for this is that the commanders-in-chief of the strategic forces (navy, air force, and Strategic Rocket Forces) decided to disobey all orders from the coup plotters and were reportedly capable of blocking a launch command when the Kazbek system was in the manual mode. In addition, the acting President during the coup, Gennadiy Yanayev, probably did not have the technical ability to use the Cheget because Gorbachev's nuclear suitcase was rendered useless before it was taken and loyalists in the General Staff refused to give Yanayev the ability to use any additional Chegets. This incident is very troubling, however, and has caused analysts to wonder what might happen in a similar, better-coordinated coup attempt.

Risk of a Regional Leader or Military Commander Revolting

Russia's many regional governors have become increasingly autonomous over the last decade, and there is increasing concern that the central government will be unable to maintain control. If these trends continue, it is possible that a regional leader, or a high-level regional military commander, might decide to revolt against the central government. During such a revolt, a leader might be quite tempted to seize the nuclear weapons located in his region.

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146 Blair, Global Zero Alert, p. 20.
147 Ibid., p. 82.
149 Blair, Logic of Accidental Nuclear War, p. 86.
151 Since his election as Russian President, Vladimir Putin has attempted to re-consolidate power, but it remains to be seen whether this attempt will be successful. Although in June 2001, Putin managed to push through legislation to strip regional leaders of their seats in parliament and replace them with appointed legislators, the regional leaders are still struggling to resist the central controls. See Associated Press, "Putin Suffers Setback in Effort to Rein in Regions," New York Times, June 28, 2000; Peter Baker and Susan B. Glasser, "Regions Resist Kremlin Control: Governors Cling to Power In Defiance of President," May 31, 2001, p. A01.
Such a revolt would probably require the collaboration of the regional military units. But the military units might in fact be tempted to join such a revolt, because they appear to be increasingly loyal to the regional governments and increasingly discontent with the central government. The military has been hit particularly hard by the recent economic crisis, and the regional governments have generally done more to ease the plight of the military units in their territories than the central government has.\(^{153}\) According to Daniel Gauré, a former Pentagon official now with the Center for Strategic and International Studies, because military allegiance is increasingly linked regionally, there is a significant risk that the center will not hold.\(^{154}\)

Since a rebellious regional leader or military commander would almost certainly want to target the nuclear weapons against Moscow, he would probably prefer to seize tactical nuclear weapons, rather than strategic ones. And it would probably be easier for him to use the tactical weapons, because Russia's strategic weapons generally contain sophisticated use-control devices, while some tactical weapons reportedly contain only very crude devices, and others might not contain any at all.\(^{155}\) If there were tactical nuclear weapon storage facilities located in a rebelling region, there could be an extreme risk that the central government would lose control of these weapons.

**Theft of Nuclear Weapons**

While the risk of theft of Russia's *deployed* strategic nuclear weapons is still relatively small, many of Russia's strategic and tactical nuclear weapons located in central storage facilities could be at some risk of theft. In addition, due to the START initiatives, Russia is presumably moving a number of nuclear weapons to its serial production facilities for dismantlement and destruction. Nuclear weapons are at greatest risk during transportation and require extensive security to ensure that they are properly protected. Most available information indicates that Russian nuclear weapons are still relatively safe;\(^{156}\) but there are a number of troubling indications that the security of these weapons may be eroding.

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\(^{154}\) Daniel Gauré, quoted in Mann, "Nuclear Risks," p. 60.


\(^{156}\) See, for example, the testimony of General Eugene Habiger after he visited several Russian nuclear weapon facilities (Habiger, DOD News Briefings, November 4, 1997 and June 16, 1998).
Most of these central nuclear weapon storage facilities were built 30–40 years ago, and many reportedly require reconstruction. In 1996, the Russian Ministry of Defense (MOD, the agency responsible for Russian nuclear weapons) reported that the reserves for technical maintenance of these facilities were nearly exhausted. That year, the MOD requested 640 billion rubles for security operations and R830 billion for the development and purchase of physical protection equipment, but it only received R110 billion for security operations and R53 billion for physical protection equipment. While the MOD might have exaggerated the amount of money it needed, one cannot help being troubled by the large gap between the funding requested and the funding actually delivered. Moreover, one can only suspect that the situation worsened during Russia's economic crisis in 1998, and it is not clear whether the Russian government has subsequently increased funding to the MOD.

One can also draw some conclusions about the security of Russian nuclear weapons from the current projects in the U.S.-sponsored Cooperative Threat Reduction (CTR) program. One part of CTR is the nuclear weapons protection, control, and accounting (WPC&A) program, which helps Russia ensure the security of its nuclear weapons during transportation, storage, and dismantlement.

In the early years of the CTR program, U.S. assistance focused on helping Russia consolidate its nuclear forces. It therefore helped Russia improve the security of Russian nuclear weapons during transportation to centralized storage sites. Between 1992 and 1996, the United States provided Russia 3,020 armored blankets and 150 “supercontainers” to improve protection of warheads during shipment, modification kits to improve security for 100 nuclear weapon railcars, and 15 guard railcars. The U.S. Defense Department also delivered emergency response training and equipment “in the event of a nuclear weapons transportation incident.” Although these efforts are significant, it is not clear that they are enough to ensure the security of Russian nuclear weapons during transport. According to Vladimir Orlov, Director of the Center for Political Research in Russia, and editor-in-chief of the Russian nonproliferation journal

158 Ibid., p. 2.
Yaderny Kontrol, in 1997 Russian military units had only 17% of the cargo trucks the military needed for transportation of nuclear weapons. Orlov also reports that between 1993 and 1996, 223 special railcars for nuclear warhead transport were retired and only 38 railcars were supplied to replace them. This shortage of transportation vehicles could cause dangerous delays in the shipment of nuclear weapons.

In the later years of the CTR program, the focus has shifted to improving the security of Russian storage facilities. The WPC&A program is helping Russia design computer tracking systems for warheads and has provided software for assessing storage site vulnerabilities. It is also helping the MOD improve the security of over 50 storage facilities, providing fences and sensors as “quick fixes” for security problems. The fact that the U.S. DOD feels that these improvements are necessary indicates that there are problems with the security of Russia’s nuclear weapon storage facilities, and the fact that the DOD calls these upgrades “quick fixes” implies that the security problems might in fact be relatively severe. It is necessary to emphasize that Russia’s current security for its nuclear weapons is still probably fairly strong, but given the evidence of Russia’s deteriorating facilities and security systems, one must wonder whether it will remain strong in the future.

The consequences of the theft of nuclear weapons could be quite serious. As noted, although Russia’s strategic nuclear weapons contain sophisticated use-control devices, some of its tactical weapons might not. But even if stolen weapons do contain these use-control devices, the theft would still be very serious. Even if a proliferating country or terrorist group were unable to detonate a stolen weapon, it could still obtain the nuclear material from the weapon for use in a radiological device or for use in a new nuclear bomb, and it might also be able to use the stolen weapon to gain design information for its own weapon.

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162 Ibid., p. 2.
164 Ibid., p. 65.
Conclusions about the Risks of Unauthorized Use

There do seem to be increased risks of a loss of central control over Russia’s nuclear weapons, especially during times of acute economic or political crisis. And while the risks are still relatively small (except perhaps for the theft of nuclear weapons), they could increase suddenly and dramatically if Russia’s political and economic difficulties worsen.167

Moreover, if the deterioration of the Kazbek system continues, Russia might decide to adopt a more “delegative” command system, where authorization codes are distributed to officials further down the chain of command in order to reduce pressures in the command system that might arise during crisis situations.168 Such a command system could significantly increase risks of unauthorized use, because greater numbers of people would have access to the launch codes for Russia’s nuclear weapons.169

One must keep in mind, however, that the loss of central control over a nuclear weapon does not necessarily mean that the weapon will be used.170 But the use of nuclear weapons as tools in a domestic political struggle is bound to have a destabilizing effect, both domestically and internationally, and could increase the likelihood of preemptive nuclear strikes, panic-launches, and nuclear accidents.171 In addition, the theft of nuclear weapons by proliferating states or terrorist groups could be extremely destabilizing because they would not have the experience or capabilities necessary for handling these weapons safely.172

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167 The Rumsfeld Commission determined that either a breakdown of control at the apex of power (at or above the level of the General Staff) or a revolt by a regional leader could increase the risk of an unauthorized use of nuclear weapons (Steve Maaranen, Rumsfeld Commission Staff, interview by author, May 14, 1999). Because the Rumsfeld Commission only studied the risks associated with strategic ballistic missiles, however, it did not address the risks of theft of nuclear cruise missiles or tactical nuclear weapons.

168 Woolf and Wilson, “Russia’s Nuclear Forces,” p. 27.

169 Ibid., p. 27. For the risks associated with “delegative” command systems, see Feaver, “Command and Control in Emerging Nuclear Nations.” pp. 168–170.


172 Moreover, deterrence would be largely ineffective against terrorists because they usually have no territory that can be targeted by nuclear weapons. See Bueno de Mesquita and Riker, “Selective Nuclear Proliferation,” p. 304; Mearsheimer, “Back to the Future,” p. 39. And terrorists would be quite likely to use a stolen nuclear weapon—either as a direct means of attack or as a tool for nuclear blackmail.
Inadvertent Use: Russia’s Aging Early-Warning System

Both accidental and unauthorized use must be distinguished from an “inadvertent” use of a nuclear weapon, where the use is intentional and ordered by the people who have legitimate authority to order its use, but the order is based on misinformation. The risk of an inadvertent launch of Russia’s nuclear forces has increased significantly in recent years. As we have seen, there are currently large gaps in surveillance by Russia’s early-warning satellites, and there is a great risk that Russia would not be able to correctly identify a launch of U.S. ICBMs or SLBMs. In addition, because there are very few early-warning radar stations in Eastern Europe, Russia would have even less time to decide whether or not to launch their missiles before an attack arrived. This serious time constraint, combined with Russia’s option of LOW, greatly increases the chance that Russia might inadvertently retaliate against a supposed missile attack that never actually occurred.

To make matters worse, Russia’s deteriorating BMEW system can no longer give much redundant information about a missile attack. Thus, if one sensor detects a missile launch, Russia’s early-warning centers would be less able to verify whether or not the detection is mistaken. Moreover, multiple radar sensors increase confidence in the data that is used to calculate the trajectory of the missile or rocket. With fewer sensors, there is increased risk that Russia’s early-warning centers could conclude that a missile was heading for Russia when it actually was not.

These kinds of miscalculations are not merely far-fetched scenarios. There actually have been cases where Russia’s early-warning sensors mistakenly detected an incoming missile attack. In one case, on September 26, 1983—soon after Russia’s BMEW system became active—one of Russia’s early-warning satellites falsely detected a launch of five U.S. Minuteman ICBMs. After several tense minutes, the officer on duty decided that the satellite detection was mistaken.173

A second, rather famous example of a failure in Russia’s early-warning system is the Black Brant XII incident.174 On January 25, 1995, the United States and Norway jointly launched the Black Brant XII, a rocket designed to study the Northern Lights. However, Russia’s early-warning radars misidentified this rocket as a possible U.S. SLBM, and the crew at

174 For a study of this incident and its implications, see Forden et al., “False Alarm, Nuclear Danger,” pp. 1–12.
the radar station notified central early-warning stations of a possible missile launch. These early-warning stations, in turn, alerted the highest levels of the Russian command by sending a message to their nuclear suitcases. At that point, President Boris Yeltsin, Defense Minister Pavel Grachev, and the Chief of the General Staff Mikhail Lolesnikov had a telephone conference about what action to take. While it is not exactly clear what they decided to do, there is some evidence that the Russian forces were put on a higher alert level during this crisis. Nikolai Devyanin, chief designer of the Russian nuclear suitcase, reportedly said that Russia’s command-and-control system was placed in combat mode. If this is true, then the Cheget-holders may have issued the preliminary command, activating the communication links for the Kazbek system.

Although some analysts have argued that the Russian BMEW system performed as it was supposed to during this incident, others have questioned why it identified the launch as a possible missile attack when the rocket trajectory was headed away from Russia. Whatever the case may be, an early-warning system that cannot distinguish between a benign rocket launch and an actual nuclear missile attack—combined with a policy that allows for LOW—poses serious risks of inadvertent launches. And these risks have probably increased since the 1995 incident, as Russia’s early-warning system has continued to deteriorate.

Conclusions about Inadvertent Use

The deterioration of Russia’s early-warning radar and satellite systems has undeniably increased the likelihood of an inadvertent launch of Russia’s nuclear weapons. These risks are smaller than they might otherwise be, however, because the Russian early-warning system takes into account general political circumstances in addition to the technical information from radars and satellites to assess whether there is an incoming missile attack. Because Russian leaders have stated repeatedly that they believe there is a greatly reduced likelihood of a nuclear attack

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178 Forden et al., “False Alarm, Nuclear Danger,” pp. 1–12; Blair, Global Zero Alert, p. 47. Moreover, the Norwegian government reportedly had sent a letter to Russia notifying it of the impending rocket launch, but the letter was never given to the radar crews (Hoffman, “Cold-War Doctrines Refuse to Die,” p. A1). If this report is true, there clearly would have been serious bureaucratic problems in Russia’s BMEW system.
179 Forden et al., “False Alarm, Nuclear Danger,” p. 3.
180 Ibid., p. 9.
from the United States, they would be more likely to question the information from early-warning sensors.\textsuperscript{181}

Nevertheless, the diminished number of early-warning sensors has further reduced the time Russian leaders would have to decide whether or not a detected attack is real before they would need to launch their own missiles. If the Russian BMEW system were to continue to deteriorate, the danger of inadvertent launch would probably increase.

If current plans to build a joint U.S.-Russia early-warning station are implemented, some risks of inadvertent launches would be reduced. But the greatest dangers associated with Russia's deteriorating BMEW system could still arise if relations between the United States and Russia were to sour again. Obviously, the Russians would be less likely to trust the information from a joint early-warning station if they feared that the United States might attack them. Thus, if relations between the United States and Russia were to worsen, or if Russia feared that the United States was trying to capitalize on a situation of acute civil strife in Russia, the risk of an inadvertent launch of Russia's nuclear forces could significantly increase.\textsuperscript{182}

\textbf{Part II: Russia's MPC&A}

As far as is known, nuclear materials were very secure during the Soviet era. The Soviet system was quite simple: it maintained very strict controls over its population and relied on the presence of guards, gates, and guns at its nuclear facilities. Military nuclear facilities were generally inside the closed cities, which were located in remote areas and were surrounded by heavily-guarded fences. Access to the cities was strictly controlled, and only authorized personnel were permitted to enter.

Most experts believe that the physical protection of Soviet nuclear facilities was excellent. There was very little risk of an outsider attack on a facility because the nuclear cities were too well guarded and the society was too closely controlled. There was also very little risk of insiders stealing materials from nuclear facilities. The highly privileged and patriotic personnel working at the nuclear cities had little incentive to steal nuclear materials in the first

\textsuperscript{181} James Rubin, Department of State Daily Briefing, February 10, 1999.

\textsuperscript{182} The Rumsfeld Commission concluded that the risks of an inadvertent launch could significantly increase during such scenarios, especially given Russia's deteriorating early-warning system (Rumsfeld Commission Report, section II C2; Steve Maaranen, Rumsfeld Commission Staff, interview by author, May 14, 1999).
place. But even if an insider had wanted to steal materials, he would have found it extremely
difficult to sell them because the KGB closely monitored everyone’s actions very closely.

After the collapse of the Soviet Union, however, things changed dramatically. According
to Matthew Bunn, “A security systems designed for a single state with a closed society, closed
borders, and well-paid, well-cared-for nuclear workers has been splintered among multiple states
with open societies, open borders, desperate, underpaid nuclear workers, and rampant theft and
corruption.”183 The MPC&A at Russian nuclear facilities was simply not designed to protect
materials in this new political and economic situation. As a result, the personnel at nuclear
facilities now had greater incentives and greater opportunities to steal nuclear materials. And
some personnel gave in to this temptation. Russian Prime Minister Mikhail Kasayanov admitted
in September 2000 that twenty-one attempts to steal registered nuclear materials occurred
between 1991 and 1999.184 Several of these attempts resulted in the theft of fissile materials,
including 1.5 kilograms of HEU from the “Luch” facility in Podolsk, Russia, in 1992; 1.8
kilograms of HEU from the Andreeva Guba naval base in July 1993; 4.5 kilograms of HEU from
the Sevmorput naval shipyard in November 1993; over 360 grams of Pu, seized in a German
“sting” operation on a plane from Moscow, in August 1994; and 2.73 kilograms of HEU, seized
in Prague in December 1994.185 The most recent confirmed theft attempt occurred in December
1998, when employees at a Chelyabinsk facility reportedly were stopped just as they were about
to steal 18.5 kg of weapons-usable fissile materials.186 One also cannot rule out that additional
attempted or successful thefts have occurred, but they were never discovered or never confirmed
by the Russian government.187

183 Matthew Bunn, The Next Wave: Urgently Needed New Steps to Control Warheads and Fissile Materials
184 Vladimir Kucherenko, “Russian Nuclear Material Monitoring System ‘Far From Ideal’,” Rossiyskaya Gazeta,
Presentation Before the Permanent Subcommittee on Investigations, U.S. Senate Committee on Governmental
186 Bunn, The Next Wave, p. 17. Months after the incident, Viktor Yerastov, director of the department of
accounting and control of nuclear materials at the Russian Ministry of Atomic Energy (Minatom), confirmed that
this attempted theft had taken place (“Nuclear Thieves Could Have Inflicted Serious Harm to the State,” Yaderny
Kontrol, November–December 1999, pp. 40–43 in the CNS Nuclear Trafficking Database, 19990950). Although
Yerastov did not specify whether these materials were weapons-usable (i.e., whether they were HEU or Pu),
Matthew Bunn argues that they were, based on Yerastov’s comments and the types of materials in a nuclear weapon.
See Bunn, The Next Wave, p. 17.
187 For a discussion of these possibilities, see Emily Ewell, “NIS Nuclear Smuggling Since 1995: A Lull in
Current Fissile Materials Stockpiles

Although precise amounts have never been confirmed, the Soviet Union is believed to have produced hundreds of metric tons of highly-enriched uranium (HEU)\textsuperscript{188} and plutonium (Pu). Approximately half of these amounts are contained in weapons, while the remaining fissile materials (as much as 800 tons) are stored in more than 300 buildings in over 50 sites across Russia.\textsuperscript{189} These amounts of stored fissile materials will undoubtedly increase as Russia continues dismantling its nuclear weapons, according to START commitments. The following is a summary of the different types of sites believed to contain fissile material and the Russian agencies responsible for fissile material security.\textsuperscript{190}

Defense Facilities

During the Cold War, the Soviet Union created a massive nuclear complex for its nuclear weapon program. At least 221 facilities were built as part of the Soviet nuclear weapons complex, with a large percentage located in Russia. Most of the Russian defense facilities are located in the 10 formerly closed or secret cities. These facilities engaged in a number of different activities, including mining and milling uranium ore, uranium enrichment, producing and processing plutonium, assembling nuclear weapons, and disposing and storing nuclear waste.\textsuperscript{191} Some of these facilities are still used as part of Russia's defense complex and some have been shut down.\textsuperscript{192} Massive amounts of fissile materials are still located at most of these facilities.

\textsuperscript{188} HEU is uranium enriched to a level of 20 percent or greater of the isotope uranium-235, the amount necessary for a nuclear explosion.

\textsuperscript{189} Although the Department of Energy previously estimated this amount to be 650 tonnes, the DOE's Acting Deputy Administrator for Defense and Nuclear Nonproliferation, Rose Gottemoeller, told a congressional subcommittee on March 21, 2000 that the actual amount was closer to 800 tonnes. See "More Russian Material at Risk Than Previously Thought," \textit{Nuclear Weapons and Materials Monitor}, no. 4 (April 7, 2000), pp. 4–5. For an assessment of the number of sites containing fissile materials, see Oleg Bukharin, Matthew Bunn, and Kenneth Luongo, \textit{Renewing the Partnership: Recommendations for Accelerated Action to Secure Nuclear Material in the Former Soviet Union}, Russian American Nuclear Security Advisory Council, August 2000, p. 6.

\textsuperscript{190} For a chart listing all the Russian sites believed to contain weapons-usable fissile materials, see Jones et al., p. 45–47.

\textsuperscript{191} Federation of American Scientists (FAS) web site: <http://www.fas.org/nuke/guide/russia/facility/nuke/overview.htm>. For a list of main nuclear defense sites in the FSU and their activities, see the FAS web site: <http://www.fas.org/nuke/guide/russia/facility/nuke/index.html>.

\textsuperscript{192} For example, of the three plutonium production facilities, Chelyabinsk-65, Tomsk-7, and Krasnoyarsk-26, Tomsk-7 still has two functioning reactors and Krasnoyarsk-26 still has one. These reactors are being used to produce heat and electricity for their populations.
Naval Fuel

Because the Russian navy uses HEU for its nuclear-powered ships (enriched between 20 and 90 percent U-235), there are large amounts of very attractive fissile materials located at some of Russia’s naval bases, particularly at the bases for its Northern and Pacific Fleets. Fresh nuclear fuel rods are shipped to these facilities by rail, where they are stored until needed. The fuel rods are stored in land-based facilities and storage ships. These facilities have received a great deal of attention since 1993, when 4.5 kilograms of uranium (enriched to 20% U-235) was stolen from a Northern Fleet storage facility.

Civilian Facilities

The concept of a “civilian” nuclear complex is somewhat new to Russia. During the Soviet era, many nuclear reactors (such as the plutonium production plants) were used both to produce heat and electricity and to produce weapons-grade fissile materials. In recent years, however, Russia has made efforts to distinguish between its defense and civilian nuclear facilities. Some of the civilian facilities produce or use only low-enriched uranium (LEU), which cannot be used to make nuclear weapons, but some of them use HEU. While all of Russia’s civilian nuclear facilities could be targets for nuclear terrorism, a number of them also contain highly attractive materials for theft.

Russian Agencies that have Authority over Fissile Materials

The Russian Ministry of Defense (MOD) has responsibility for monitoring “nuclear and radiation safety of nuclear weapons and nuclear power units of military designation.” The MOD is therefore responsible for the security of all deployed nuclear weapons and all nuclear warheads and all naval nuclear fuel (which is primarily HEU). Within the MOD, the 12th Directorate has responsibility for all security of all assembled nuclear weapons. It therefore

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194 Ibid., p. 43.
oversees the security of deployed nuclear weapons, nuclear weapon storage facilities, and nuclear weapons during transport.\textsuperscript{197}

Russia’s Ministry of Atomic Energy (Minatom) has authority over all defense-related fissile materials. It is therefore responsible for security of weapons-related processing plants and Russia’s serial production facilities (where warheads are assembled and disassembled).\textsuperscript{198}

The nuclear regulatory agency Gosatomnadzor (GAN) has authority over all civilian nuclear fuel. It therefore has responsibility for security of fissile materials at Russia’s nuclear power plants.\textsuperscript{199} GAN is also responsible for nuclear safety at Russia’s civilian nuclear facilities.

Specific Weaknesses in Russia’s MPC&A After the Soviet Collapse

The system of fissile material security at the former-Soviet nuclear facilities was severely weakened after the collapse, as guard forces weakened and the strict societal controls largely disappeared. The MPC&A system that Russia inherited from the Soviets simply did not come close to meeting Russia’s new MPC&A needs. A resilient MPC&A system must be strong in two distinct areas: physical protection, and material control and accounting (MC&A). Physical protection systems are designed to deter or defeat any external attacks by groups or individuals who want to steal nuclear materials or sabotage nuclear facilities. MC&A systems, on the other hand, are designed to detect a theft of nuclear materials once it has occurred, by keeping very close measurements of the amounts of materials in each facility and by detecting whether any materials are moved or taken.\textsuperscript{200} The following is a description of the some of the weaknesses in Russia’s MPC&A in both these areas.

Physical Protection

The physical protection of Russian nuclear facilities often varied widely. While the protection at nuclear weapon assembly and storage facilities was still fairly good, the protection

\textsuperscript{197} Arkin et al., \textit{Taking Stock}, p. 29.

\textsuperscript{198} Oleg Bukharin, “Soft Landing for Bomb Uranium,” \textit{Bulletin of the Atomic Scientists}, vol. 49, no. 7 (September 1993), p. 46, <http://www.bullatomsci.org/issues/1993/93Bukharin.html>. The distinction between MOD authority over nuclear weapons and Minatom’s authority over fissile materials becomes somewhat blurred at the serial production facilities. MOD still oversees the nuclear weapons as they enter and exit the facilities, and maintains some presence at the facilities. At some point, responsibility is transferred to and from Minatom.

\textsuperscript{199} This distinction between defense- and civilian-related fissile materials is relatively new. During the Soviet era, there was no such distinction. During the early 1990s, there was a great deal of contention between Minatom and GAN over who had responsibility over defense-related nuclear materials.

\textsuperscript{200} For international standards for physical protection see INFCIRC/225/rev.4.
of many of Russia's production reactors and naval facilities were often reported to be quite weak. For example, many facilities containing HEU and Pu had open first floor windows with no bars on them; there were often large holes cut into the walls for ventilation; the doors on the buildings and the vaults were often made of wood; and the fences around nuclear facilities were often dilapidated or damaged, and many contained large holes.\textsuperscript{201}

Many buildings were also not equipped with surveillance or alarm systems.\textsuperscript{202} And even when a building did have an alarm, the system was typically quite old and often no longer operational.\textsuperscript{203} According to Vladimir Orlov, Director of the Center for Political Research in Russia and editor-in-chief of the Russian nonproliferation journal \textit{Yaderny Kontrol}, 70\% of the available security equipment at Russian facilities was obsolete as of 1997, and 20\% had been working twice to three times its service life.\textsuperscript{204} In addition, because the Soviets had not engaged in extensive designing and testing of their physical protection systems, it was often possible to bypass or defeat alarm systems.\textsuperscript{205}

As noted, the physical protection of Soviet facilities was mainly based on an extensive guard force. After the collapse of the Soviet Union, however, many facilities were forced to cut costs by reducing the number and quality of guards at their facilities. Many facilities reportedly refused to enter into expensive contracts for guard forces with the Ministry of Internal Affairs. Instead, they hired cheaper, but often poorly-trained civilian guard forces.\textsuperscript{206} There were typically no guards at the individual buildings in a nuclear facility, though there were usually guards around both the city and the perimeter of the nuclear facility. To make matters worse, guards stationed at Russian facilities were typically not equipped with radios.\textsuperscript{207} Any guard on

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\textsuperscript{203} Bukharin and Potter, "Potatoes were Guarded Better," p. 49.

\textsuperscript{204} Orlov, "Nuclear Blackmail," p. 1

\textsuperscript{205} Ibid., p. 2


\end{footnotesize}
patrol must have a radio to notify a central guard station if he sees anything unusual. As it was, if a guard needed to report anything, he would need to run back to the guard station, often located up to a kilometer away.

In a 1993 report on fissile material security, Russia’s nuclear regulatory agency, Gosatormnadzor (GAN), identified many of these same problems with Russia’s physical protection:

- Lack of physical protection standards;
- Focus on the protection of a site’s outer perimeter and inadequate defenses of buildings and facilities inside the fence;
- Inadequate protection of guards from small-arms fire (lack of bullet-proof guard posts or protected bunkers);
- Lack of vehicle barriers;
- Lack of portal monitors to detect fissile materials, explosives, or weapons;
- Inadequate communication between individual guards, between patrol units and the central alarm station, and between the facility and the off-site law-enforcement force;
- Inadequate manpower and low salaries of security personnel.\(^{208}\)

**MC&A**

The MC&A at Russian nuclear facilities was often even worse than the physical protection. In fact, many facilities did not have a precise MC&A system at all, because the Soviet fissile material production plants were focused on producing large amounts of fissile materials and had little time for precise MC&A procedures.\(^{209}\)

Most facilities did have massive paper records of the fissile materials produced, but these records were not very precise. Indeed, they were never intended to keep an exact inventory of the materials produced or stored at a given facility and used an accounting system based on the financial value of the materials rather than specific amounts of materials.\(^{210}\) But even if these records had been accurate, it still would have been nearly impossible to detect a theft of

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\(^{210}\) Roumiantsev, quoted in Ibid., p. 20.
materials, since one would have had to track the amounts of materials through hundreds of pages of records.\textsuperscript{211}

In fact, Russian facilities often did not even know what category of nuclear material they had stored there.\textsuperscript{212} This is a basic fact that is necessary for designing an MPC\&A system, for it determines the attractiveness of the material for theft and therefore determines what kinds of controls must be in place. The IAEA, for example, recommends that facilities containing Category I materials (substantial amounts of pure Pu or HEU) have much stronger MPC\&A than those containing Category III materials (very small amounts of Pu or HEU, or substantial amounts of low enriched uranium).\textsuperscript{213} Nuclear material shipped to Russian facilities typically contained a "manufacturer's passport" value, which states the type and amount of nuclear material in each container, but this measurement system did not work well for materials that were not in a convenient itemized form, such as small pellets, liquids or powders.\textsuperscript{214} In addition, the passport values were often incorrect, due to measurement errors, time constraints, or intentional overstatements.\textsuperscript{215} When materials entered a facility, typically there was no independent verification of passport values; they were simply assumed to be correct.\textsuperscript{216}

To make matters worse, because a production plant and its personnel were subject to harsh penalties if the plant did not meet its production quotas, there was usually a back room in production facilities where extra HEU or plutonium was stored in case the facility did not meet the quota for a particular month. Because there were no precise records of these materials, they could be stolen without anyone noticing. And over time, facilities would often lose track of where they put these materials.\textsuperscript{217}

\textsuperscript{211} Ron Auguston, quoted in "Russian-American Collaborations," p. 34.


\textsuperscript{213} See the IAEA recommendations for the different categories of nuclear material in INFCIRC/225.

\textsuperscript{214} Roumiantsev, quoted in "Effective State MPC\&A System," p. 20.


As a result of these procedures, most Russian nuclear facilities did not have any accurate idea of the amounts of materials they contained after the Soviet collapse. This is the very first step in creating an MC&A system—if one does not know the precise amounts of materials in a given facility, one cannot know if any is missing.

In addition, there were no procedures for tracking materials once they were inside a given facility. Russian nuclear facilities did not have Material Balance Areas (MBAs), which are accounting procedures typically used in Western MC&A systems. In the Western system, nuclear materials are measured (by radiation and mass measurements) whenever they are moved from one designated Material Balance Area to another. Thus, if any material is missing, one can tell when and where the loss occurred. In Russian sites, however, there was generally free movement of materials throughout a facility, except when the materials were placed in a storage vault. It would therefore have been very hard to detect a theft of materials or track down the people who might have stolen it. Moreover, even the materials stored in vaults were seldom counted or measured to verify that none was missing.

Finally, Russian nuclear facilities rarely had material control equipment in place to ensure that materials could not be moved or stolen without detection. There were rarely any portal monitors to detect if someone tried to leave a nuclear facility with nuclear materials. The seals on material storage containers were generally made of wax or a soft lead and could be easily removed and replaced with another seal. There were typically no tamper-indicating seals or identification codes on the containers to show if any seals had been broken or replaced.

In the 1993 report on nuclear safety and security, GAN summarized these problems in Russia’s MC&A:

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Material loss limits often are not substantiated and do not exclude unaccounted losses within the authorized limits;
- The principle of personal responsibility often is not enforced;
- Measurement of nuclear materials in the process of inventory taking and in transfers of materials between facilities are inadequate;
- Measurements of waste, scrap, and hold-up of nuclear materials are inadequate;
- There are no uniform accounting procedures or computerized accounting systems.\textsuperscript{222}

The Early History of U.S.-Russian MPC&A Collaborations

As reports of potential weaknesses in Russia's nuclear security began surfacing in the early 1990s, U.S. officials determined that it was in the U.S. interest to help Russia secure its nuclear weapons and fissile materials. Shortly after the 1991 coup attempt, Senators Sam Nunn and Richard Lugar attempted to gain Congressional support for a program that would help improve Russian nuclear security.

The Cooperative Threat Reduction (CTR) or the “Nunn-Lugar” Program

In November 1991, the U.S. Congress passed the bill sponsored by Nunn and Lugar allocating four hundred million dollars of Defense Department funds to assist the Newly Independent States (NIS) with the “transportation, storage, safeguarding, and destruction of nuclear and other weapons [and with] the prevention of weapons proliferation.”\textsuperscript{223} This bill gave rise to the Cooperative Threat Reduction (CTR) program (also called the Nunn-Lugar program, after its sponsors). In addition to providing funding and assistance for the elimination of delivery systems, the CTR program also helped Russia with the security of its nuclear weapons, especially during disassembly, and helped install MPC&A systems at civilian nuclear institutes in Russia.\textsuperscript{224}

Negotiations for the Nunn-Lugar program began at a meeting in March 1992 between representatives of the Russian and U.S. governments. Unfortunately, these negotiations progressed slowly and were characterized by frustrating delays. Although there were significant problems on both sides, the main responsibility for these delays appears to lie with the Russian


\textsuperscript{223} Quoted in “Russian-American Collaborations,” p. 74.

\textsuperscript{224} Ibid., p. 74.
government. One problem was that there were organizational problems within the Russian government as to what bureaucracy was responsible for the various parts of the nuclear program. Moreover, the Russian Ministry of Atomic Energy (Minatom), the main organization responsible for Russia's nuclear materials, was often unwilling to relinquish any authority because this would reduce its power. Indeed, there are numerous instances of "turf battles" between Minatom and the newly-created nuclear regulatory agency GAN over which agency should have authority over given projects.

The most serious obstacle in the Nunn-Lugar negotiations, however, was that both the Russian government and Minatom refused to admit that there was a problem with their nuclear material security, since doing so would in effect be an admission of incompetence. This obstinacy made it very difficult to justify the millions of dollars allocated to the CTR program and caused great delays in the implementation of many CTR projects.

After a frustratingly slow start, however, the CTR program did eventually overcome many of the negotiation obstacles, but this was not before a second approach for improving Russia's nuclear security had been developed.

**U.S.-Russia Lab-to-Lab Collaborations and the MPC&A Program**

In 1993 and 1994, scientists at Los Alamos National Laboratory (LANL) began discussing with their counterparts at Russian scientific laboratories the possibilities for laboratory-level scientific collaborations to improve Russian MPC&A. In 1994, the Department of Energy allocated two million dollars for these collaborations, and a delegation from LANL

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226 White, quoted in "Russian-American Collaborations," p. 35.


went to Russia to negotiate and sign contracts for improving Russian MPC&A systems.\textsuperscript{211} Once these contracts were approved by the central governments in each country, the U.S. and Russian nuclear laboratories began implementing the MPC&A upgrades. These collaborations quickly took on lives of their own and were eventually organized into an overall MPC&A program overseen by the Department of Energy.\textsuperscript{212}

The lab-to-lab program achieved almost immediate successes, in large part because it was able to avoid many of the bureaucratic obstacles that delayed the CTR program.\textsuperscript{213} The main reason for this was that the lab-to-lab negotiations were based on mutual trust among U.S. and Russian scientists, built up through previous scientific collaborations in the early 1990s.\textsuperscript{214} As a result, the Russian scientists were more willing than their government to admit that there was a problem with Russia's fissile material control. Nevertheless, even then, it was not until June 1994 that scientists at Arzamas-16 admitted to Sigfried Hecker (Director of LANL at the time) that there was a problem—more than two years after he had broached the subject to them.\textsuperscript{215}

\textbf{An Example of MC&A Upgrades: The Plutonium Production Facility at Krasnoyarsk-26}

Krasnoyarsk-26 (or K-26) is one of the former-Soviet "nuclear cities."\textsuperscript{216} It was established in 1950 to produce plutonium for Soviet nuclear weapons. K-26 has a population of nearly 100,000. The actual Pu production facility is a huge underground complex located roughly 10 miles from the residential area. It consists of three Pu production reactors; a water cooling plant; and chemical, uranium and graphite reactors. Two of the Pu production reactors at K-26 were shut down in 1992, but the third is still being used to produce heat and electricity for the city. (Russia is not believed to be using any of this new Pu in its nuclear weapons program.) K-26 contains large amounts of HEU (enriched to 90% U-235) and Pu. The underground complex contains two fissile material storage vaults, one for HEU and one for Pu.

In order to identify the risks of material diversion and the role of the MPC&A program, we will need to discuss how this facility works. All technical information about the Pu

\textsuperscript{211} "Russian-American Collaborations," p. 75.
\textsuperscript{212} Although the U.S. Department of Defense (DOD) initially had primary oversight of the program, the DOE was given official control of the program in 1996. See Jason Ellis and Todd Perry, "Nunn-Lugar's Unfinished Agenda," \textit{Arms Control Today} 27 (October 1997), <http://www.armscontrol.org/ACT/oct97/nunnoct.htm>, p. 4.
\textsuperscript{213} Hecker, quoted in "Russian-American Collaborations," p. 37.
\textsuperscript{214} White, quoted in Ibid., p. 35; Steven Younger, quoted in Ibid., p. 36.
\textsuperscript{215} Hecker, quoted in Ibid., p. 34.
\textsuperscript{216} Krasnoyarsk-26 was recently renamed as Zheleznogorsk.
production plant at Krasnoyarsk-26 was related in an interview on May 25, 1999 with Dr. Konstantin Dorofeev, head of the Russian MC&A program at K-26.

The plutonium is produced by passing many 3" x 1.5" HEU pellets through a reactor. After they are passed through the reactor, these pellets contain Pu, which needs to be separated from the rest of the materials in the pellets. The pellets are then moved to the radiochemical plant, where the Pu is removed by a Purex process. In the Purex process, spent fuel is passed through a series of large tanks, where a variety of solvents are used to separate the plutonium from the other substances.

After the Pu is removed, it is still in a liquid solution. It is moved to the Calcination Room, where it is dried. The result is a relatively pure Pu oxide powder. This powder is then placed into containers and moved to the Pu storage vault.

Proliferation Risks at K-26 before the MC&A Program

The following are the procedures and process that placed the fissile materials at risk. According to Konstantin Dorofeev, these MC&A weaknesses were typical of most nuclear facilities in the Russian nuclear complex.

The HEU is shipped to the facility in roughly one-foot square boxes. There are somewhere between 10 and 20 HEU pellets per box. Before the U.S.-Russia MPC&A program began, there were no tamper-proof seals or bar codes on the boxes. In fact, there were not even any locks on the boxes; the seals on the boxes could be removed with a screwdriver.

Before the MC&A upgrades, the accounting system for the facility was not very precise. There were no identification codes on the HEU pellets or the boxes themselves. Accounting was conducted by paper and pencil. According to Dorofeev, the accounting was about as precise as at any standard industrial production plant. There was a separate group that was responsible for accounting, but according to Dorofeev, this was not enough since the accounting personnel were not scientifically trained and did not know advanced scientific accounting techniques such as nondestructive assay or radiation measurement.

The facility did do some verification of the materials as they passed through the production process. They knew how much Pu should be produced in the reactor and the

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237 The reactor burns the HEU, producing Np-239, which quickly decays to Pu-239.
containers in the Calcination Room were weighed to make sure that roughly the correct amount of Pu was being produced. These scales were relatively crude, however, and could not obtain very precise measurements.

In Dorofeev's opinion, the containers used to store Pu were not properly accounted for. There were no bar codes on these containers or locks with separate ID codes. The locks on the containers consisted of a thin wire and a lead lock. According to Dorofeev, if someone wanted to, he could cut the wire on the lock, steal the material, and put a new lock on the empty container. Since neither the containers nor the locks had ID codes, no one would notice that the materials were missing unless they weighed the containers. But this probably would never be done because there were no thorough verification techniques to ensure that no material had been stolen after the containers had been placed in storage. The facility did conduct periodic inventories of the nuclear materials, but this was done by counting the number of containers on the shelves in the storage vault. There was no way to detect whether someone had removed materials from the containers.

Some of the MC&A Upgrades at K-26

In order to help reduce these risks, the U.S.-Russian program instituted the following MPC&A upgrades to the facility.

- Special technical accounting groups are being integrated directly into each technical department at the facility. The accounting personnel are now scientists conversant with modern, scientific accounting techniques.
- Bar codes and tamper-proof seals have been placed on the boxes of HEU pellets and plutonium. The locks on the plutonium containers have identification codes so that it is possible to verify that a given lock has not been cut and replaced with another lock.
- The liquid storage tanks in the radiochemical plant are being fitted with tank volume measurement (TVM) equipment to measure the exact volume of the liquid in the tanks.
- New, high-precision electronic scales are being installed in the Calcination room and the storage vaults to help verify that no nuclear material has disappeared.
- A video surveillance and alarm system is being installed in the storage vaults.
- Portal monitors are being installed at all the exits. The portal monitors would sound an alarm if anyone tried to remove radioactive materials from the facility.
- A computer system is being implemented to keep track of the amounts and locations of all the nuclear materials at the facility. The computer system also records who applied the tamper-proof seals on the storage containers, when the seals were applied, when they were destroyed, and when they were last checked.
- Because the Pu storage vault is now full, the U.S. is helping the Russians build another storage vault.
Assessing the MPC&A Program: Significant Progress, but Enduring Problems

Since 1994, the MPC&A program has made continual progress. As of February 2000, it has completed MPC&A upgrades at 113 buildings in Russia and the Newly Independent States, and is currently installing systems at an additional 72 buildings. But a tremendous amount still needs to be done: current estimates indicate that only about 50 metric tons of the 800 tons of fissile materials at risk of theft are now stored in buildings with secure security systems. In addition, a number of problems have made it difficult to ensure that Russian nuclear materials are fully secure.

Physical Protection

Although significant progress has been made in upgrading physical protection, much more still needs to be done. According to William Potter, Director of the Monterey Center for Nonproliferation Studies, "at many of the central storage facilities, which are bursting at their seams with weapons-grade material, there are [still] no perimeter fences, armed guards, vehicle barriers, operational surveillance cameras, and metal detectors at entrances." What is perhaps even more troubling is that even when the modern surveillance and alarm systems have been installed at Russian facilities, they are often not used. At one facility, a new infrared intrusion detecting system was rendered ineffective because the grass was not mowed. At other facilities, high-quality surveillance systems were made useless when the facilities shut off their electricity in order to reduce their electricity bills. There are also numerous reports of guards shutting off security and monitoring systems because they decided there were too many false alarms.

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243 Woolf, "Nuclear Weapons in Russia," p. 8; Protecting Nuclear Weapons Material, p. 3.
But even if the surveillance and alarm systems have not been shut off, it is not clear that anyone would respond to an alarm at some facilities. Many facilities cannot afford to pay the guards and officers responsible for security, and there have been many reports of guards leaving their posts to look for food or refusing to respond to alarms because they lacked adequate winter clothing. 245

**MC&A**

Throughout the MPC&A program, MC&A upgrades at Russian facilities lag behind physical protection upgrades. These delays are due in part to a limited Russian acceptance of the possibility of insider theft (even though to date all nuclear material thefts from former-Soviet facilities have been carried out by insiders), and in part to the fact that it has been easier to justify physical protection upgrades to the U.S. Congress. 246 According to Matthew Bunn, hundreds of tons of fissile materials is still stored in buildings that are not equipped with portal monitors, or sensors which would set off alarms if a worker or guard were to exit a facility with plutonium or HEU. 247

Moreover, most Russian facilities still have not finished conducting a comprehensive physical inventory of their nuclear materials (the first step in creating an MC&A system), and therefore still do not have an accurate assessment of the categories or amounts of materials they contain. 248

The MPC&A program has also had difficulties establishing a “safeguards culture” in Russia, where everyone from high-level politicians to the lowest-level guard recognizes the importance of rigorous MPC&A procedures and technologies. 249 For example, Russians often still do not follow the “two-person rule,” a basic procedure that forbids any single person to be alone with nuclear materials. To help enforce the two-person rule, all vaults should have at least

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two locks on their door and no individual should have access to both keys. The Russians have long insisted that they follow the two-person rule, but their enforcement of this procedure has often been relatively lax. In fact, even at Russian facilities that have received MPC&A upgrades, U.S. program participants have often observed “exceptions” made to the two-person rule during their visits, in order to speed up access to a secure area.\(^{290}\) There have also been a number of cases where the director of a nuclear facility and other high-level managers had master keys that could open any vault.\(^{291}\) U.S. scientists have extensively emphasized the necessity for these procedures and have made some progress in convincing the Russians to follow them, but the progress can often be frustratingly slow.

**Conclusions about the MPC&A Program**

Although the MPC&A program has made significant progress in improving Russia’s nuclear security and controls, the enduring problems identified above are significant cause for concern. There appear to be several fundamental reasons for these problems. First, the scale of the problem is much bigger than early estimates indicated. Although it was initially believed that 80–100 buildings contained weapons-usable fissile materials, it turned out that there are over 400 buildings containing these materials, and most are in need of upgrades.\(^{292}\) Many frustrating problems, such as the fact that physical inventories have not been completed at many sites, can be traced to the sheer magnitude of the dilemma. Second, Russia often does not have the technological infrastructure necessary to sustain the new equipment installed at its nuclear facilities.\(^{293}\) Therefore, although some progress has been made toward implementing modern high-technology solutions, some of the most appropriate and effective upgrades have proven to be “low tech,” such as strengthened doors, locks, and bars on windows, in part because they do not require the infrastructure to maintain them.\(^{294}\) Third, many facilities are proving to be unwilling or unable to pay for the operation and maintenance of the new technologies once they

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\(^{291}\) Valentin Zharokov, quoted in “Effective State MPC&A System,” p. 21.

\(^{292}\) Kenneth Sheely and Mary Alice Hayward, “New Strategic Directions in the MPC&A Program,” paper presented at the 40\(^{th}\) Annual Institute of Nuclear Material Management Conference, p. 2.


\(^{294}\) Ibid., p. 6.
are installed. Finally, and most troubling, the Russians often do not understand, or simply do not see the necessity for, the new MPC&A technologies and procedures.255

These problems have created significant obstacles to the continued success of the MPC&A program. But given the serious consequences of fissile material theft and nuclear terrorism, continued effort should be devoted to improving Russia's fissile material controls. Further steps in the MPC&A program should include efforts to solve the specific problems outlined above by consolidating materials to fewer locations, improving Russia's technological base, and cultivating a safeguards culture at Russian nuclear facilities.256

Part III: Conclusions

The Russian case gives us important empirical evidence by which we can improve our understanding of the effects of domestic upheavals on nuclear controls. It provides insight in two fundamental areas. First, the Russian case demonstrates how domestic upheavals can weaken command structures, communication networks, and early-warning systems. In the most extreme cases, domestic upheavals can erode the allegiance of military units possessing nuclear weapons, and could even lead to nuclear coups.257 Alternatively, the country can fragment, creating new nuclear powers that have inadequate experience controlling nuclear weapons.258 But even in less severe cases, domestic crises can undermine necessary resources and manpower for the maintenance and repairs of command networks and early-warning systems. These factors can significantly increase risks of accidental, unauthorized, and inadvertent use of nuclear weapons.

Second, the Russian case demonstrates how domestic upheavals can significantly increase the risks of "nuclear leakage," in which nuclear weapons or fissile materials are stolen for sale on the black market. Although nuclear leakage has not been directly addressed in the context of the proliferation debate, these risks are very serious and are thus directly relevant to the debate. As we have seen, in order to prevent nuclear leakage, NWSs must have effective

257 Dunn, "'Nuclear Coup d'Etat,'" pp. 36–50.  
WPC&A systems at their nuclear weapon storage facilities, and MPC&A at their production facilities and fissile material storage facilities. As part of their MPC&A, NWSs should also have resilient physical protection systems, which would help prevent the capture or sabotage of nuclear facilities. But the case of Russia gives us significant reason to doubt that they will. The Soviets relied heavily on the “three G’s”—guards, gates, and guns—for protecting their nuclear materials, and this system proved to be fragile after the Soviet collapse. Due to the domestic crises that have plagued Russia since the collapse, there is significant evidence that Russian nuclear facilities are vulnerable to insider thefts and terrorist attacks, thus causing them to be a potential and actual source of nuclear leakage.

It could be, however, that these problems are unique to Russia. In the following chapters, we will examine the evidence from other NWSs to determine whether their nuclear systems could potentially reveal the same weaknesses as we have seen in Russia.

260 For a similar, though brief, argument, see Feaver, “Correspondence,” p. 113.
Chapter 4: China

Why is China an Important Case to Study?

China has had a nuclear weapons arsenal since its first nuclear test in 1964. Like the United States and Russia, China is officially recognized as a nuclear weapon state by the nuclear Non-Proliferation Treaty (NPT). Although China is clearly one of the most important states to examine when assessing the probable actions of NWSs, there have been no systematic studies of China's nuclear program in the context of the optimist-pessimist debate. It is an important case to study for the following reasons.

First, a major issue in the debate is whether or not new NWSs will have done all the planning, conducted all the tests, and implemented all the technologies necessary for a resilient command-and-control system. The assumption of this argument is that established NWSs, by the mere fact that they are established rather than new, do have resilient command-and-control systems.1 Because China has possessed nuclear weapons for over 35 years, it is a useful country to test this assumption. If the nuclear optimists are correct, we would expect that China would have a very secure system of controls against accidental and unauthorized use.

Second, another topic in the debate concerns whether opaque nuclear programs will cause additional problems for emerging NWSs. While this might be true, it is useful to examine whether or not the visible proliferators, such as China, have resilient nuclear controls. As we have seen, some research suggests that the nuclear controls in United States and Russia might not have been as resilient as most optimists assume, but very little work has been done on China.

Third, China is a relatively poor country.2 It would be useful to examine whether or not economic constraints have affected China’s ability to implement adequate nuclear controls.

David Karl and Jordan Seng have argued that because poor countries will have small arsenals,

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1 See, for example, Waltz’s argument that since poor states “can build sizeable forces only over long periods of time, they have time to learn how to care for them.” Thus, Waltz implies, all a given NWS needs is time, and it will necessarily develop systems to ensure the safety and security of its nuclear weapons. See Kenneth Waltz, “Waltz Responds to Sagan,” in Kenneth Waltz and Scott Sagan, The Spread of Nuclear Weapons: A Debate (New York: W.W. Norton, 1995), p. 97.

2 According to the CIA Factbook, China’s per capita GDP in 1999 was $3,800. To put this figure in perspective, in 1999, the per capita GDP of the United States was $33,900 and Russia’s was $4,200 (even after even after Russia’s financial collapse in 1998, its per capita GDP was $4,000). See the CIA Factbook: <http://www.cia.gov/cia/publications/factbook/indexgeo.html>. These amounts are derived from purchasing power parity (PPP) calculations rather than from conversions of official currency exchange rates. The PPP method “involves the use of standardized international dollar price weights, which are applied to the quantities of final goods and services produced in a given economy” (ibid.).
potential command-and-control problems will be easier to solve. We will examine whether this was the case in China.

Fourth, Seng argues that countries with potential political instability will actually tend to have stronger command and control over their nuclear weapons than other NWSs. Because China has seen a great deal of political turmoil since its revolutionary beginnings in 1949, it would be particularly useful to determine whether there were weaknesses in China's command and control during these crises and whether China has taken additional precautions to protect against unauthorized seizure or use of its nuclear weapons since then.

Finally, because China's fissile material controls appears to have been modeled after the Soviet system, many experts have been concerned that the Chinese system could reveal the same weaknesses as the Soviet system during similar crises. It is therefore necessary to assess the risks arising from China's current system for controlling fissile systems at its nuclear facilities. This chapter identifies a number of problems and potential weaknesses in China's MPC&A.

Part I: China's C^3I and Risks of Accidental, Unauthorized, and Inadvertent Use

China's Nuclear Arsenal

China's nuclear arsenal is currently believed to contain about 400 warheads. Of this number, about 250 are believed to be strategic weapons in a triad of long-range land-based missiles, bombers, and submarine-launched ballistic missiles, and about 150 are believed to be "tactical" weapons, presumably lower-yield bombs for tactical aircraft, artillery shells, atomic demolition munitions (ADMs), and short-range missiles. However, China is currently believed to be modernizing and expanding its nuclear arsenal, and has warned that it will expand its arsenal size by a much larger amount if the United States deploys a national missile defense (NMD). Each type of delivery system is discussed briefly below.

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See Robert S. Norris and William M. Arkin, "Chinese Nuclear Forces, 1999," *Bulletin of the Atomic Scientists*, vol. 55, no. 4 (May/June 1999), p. 79. The Chinese reportedly define missile ranges as follows: short-range, less than 1,000 km; medium-range, 1,000–3,000 km; long-range, 3,000–8,000 km; and intercontinental range, greater than 8,000 km (ibid., p. 80).

Nuclear-Capable Aircraft

China's first nuclear weapon delivery means was by aircraft, which could drop gravity bombs. China's current nuclear-capable air force includes the Hong-6, a modified Soviet Tu-16, and the Qian-5 bombers. Each of these aircraft is able to carry one nuclear gravity bomb. Because of the greater vulnerability of aircraft during delivery, China placed less emphasis on improving its nuclear-capable bombers than it has on developing its nuclear missiles. As of 1995, the People's Liberation Army (PLA) inventory basically contained aircraft of obsolete designs with a short flight radius and limited capabilities for delivering nuclear bombs to targets.

Nuclear Submarines and Submarine-Launched Ballistic Missiles (SLBMs)

China currently has one Daqingyu (Xia) class nuclear submarine, believed to be based in the North Sea Naval Fleet in Qingdao. The submarine is deployed with 12 Julang-I/CSS-N-3 SLBMs. The missiles use a solid-fuel propellant and have a range of 1,700 km with a payload of 200–300 kT. China is also developing second-generation nuclear submarines, armed with a new type of SLBM. "A new generation of nuclear powered submarines (Type 094) reportedly are scheduled for construction after the year 2000 and would carry 16 JL-2 missiles." The JL-2 missiles are still being developed, but they will have a range of 8,000 km and will allow China's submarines to target the United States from locations near China's coast. (See Table 4.1 for details on China's SLBMs.)
Land-Based Ballistic Missiles

China began its missile program in 1956 and initially received assistance from the Soviets. In that year, the Soviets sold China two R-1 missiles. Since this missile was quite primitive, however, the Soviets supplied China with two R-2 missiles in 1957. In 1958, the Soviets supplied technical blueprints and engineers to build the R-2. This missile was successfully flight tested in 1960 and was renamed the Dong-Feng-1. There are currently no DF-1 missiles deployed in China's nuclear arsenal, however.\(^{10}\)

In 1965, China embarked on the “Eight-Year Plan for the Development of Rocket Technology.” The goal of this plan was to develop missiles with ranges capable of hitting four different American targets (either U.S. bases or the United States itself). The DF-2 was designed to strike Japan, the DF-3 was designed to strike the Philippines, the DF-4 was designed to strike Guam, and the DF-5 was designed to strike the continental United States.\(^{11}\) By 1971, China had achieved its goal (although some of the missiles were not deployed until much later).\(^{12}\) After 1981, China focused on improving its land-based rocket technologies. In 1985, China successfully flight tested the DF-21, a two-stage, solid-fueled missile. This missile is a modified JL-1 submarine-launched ballistic missile (SLBM). As of 1999, China had only about 20 DF-5 missiles, and another 100 missiles with ranges from about 1,800 to 4,750 km.\(^{13}\)

In order to increase the survivability of its nuclear arsenal, China began the research and development of a second generation, mobile long-range ballistic missile system in the early 1980s. To make the missiles mobile, however, China needed to miniaturize their nuclear payloads and switch from liquid to solid propellants.\(^{14}\) As of May 2001, China was continuing to convert its missile arsenal to mobile systems. It currently has three types of road-mobile, solid-propellant missiles: the DF-21 (CSS-5),\(^{15}\) a medium-range ballistic missile (MRBM); and two types of tactical missiles (see below). In the first decade of the twenty-first century, China is expected to begin deployment of two long-range road-mobile ICBMs: the DF-31, with an

\(^{10}\) Norris et al., Nuclear Weapons Databook, Vol V, p. 360.

\(^{11}\) Ibid., p. 360.

\(^{12}\) For example, a reduced-range version of the DF-5 was first successfully flight tested in 1971, but the DF-5 was not operationally deployed until 1981 (ibid., p. 361).

\(^{13}\) Norris and Arkin, “Chinese Nuclear Forces, 1999,” p. 79.


\(^{15}\) The “DF” is the Chinese designation for these missiles, standing for “Dong Feng,” or “East Wind.” “CSS” is the NATO designation for these weapons.
estimated range of about 8,000 km, and the DF-41, with an estimated range of about 12,000 km. China reportedly flight tested the DF-31 in 1999 and twice in 2000. It is possible that both the DF-31 and DF-41 will be equipped with multiple independent re-entry vehicles (MIRVs). (See Table 4.1 for details on China’s land-based missiles.)

**Tactical Weapons**

China currently has two tactical missiles, the DF-15 (CSS-6) and the DF-11 (CSS-7). These missiles are classified as “tactical” because of their short ranges. The DF-15 has a range of 600 km and the DF-11 has a range of 280 km. Both missile types are road-mobile, contain a solid propellant, and can carry either nuclear or conventional warheads. They are intended both for use in China’s own arsenal and for export. China is believed to have exported the DF-11 (although it was called the M-11) to Pakistan in 1991. There is also some evidence that China possesses additional tactical nuclear weapons for use on the battlefield. These weapons consist of artillery shells or ADMs. (See Table 4.1 for details on China’s tactical nuclear weapons.) It is not currently known whether China’s tactical nuclear weapons are deployed in the field along with their delivery systems or kept in storage. If they were deployed in the field, they would probably be placed under the control of regional commanders.

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16 Department of Defense (DoD) Report to Congress, *Future Military Capabilities and Strategy of the People’s Republic of China*, October 1998, Section 10. Although the 12,000 km-range missile is generally referred to as the DF-41, some assessments have determined that it is an improved DF-31 and therefore refer to it as the DF-31A.


19 This appears to be the range for the DF-11 with a 1,000 kg payload. Its range would be much longer with a reasonably sized nuclear warhead.

20 When used for export, the DF-15 is called the M-9 and the DF-11 is called the M-11 (the M stands for the English word “missile”).


23 Jones et al., *Tracking Nuclear Proliferation*, p. 55.

## Table 4.1: Chinese Nuclear Weapons

<table>
<thead>
<tr>
<th>Type</th>
<th>NATO Designation</th>
<th>Number</th>
<th>Year Deployed</th>
<th>Range (km)</th>
<th>Warhead x yield</th>
<th>No. of warheads</th>
<th>Technical description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aircraft</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hong-6 B-6</td>
<td>120</td>
<td>1965</td>
<td>3,100</td>
<td>1-3 x bomb</td>
<td>120</td>
<td></td>
<td>Single-Stage; Storable liquid</td>
</tr>
<tr>
<td>Qian-5 A-5</td>
<td>30</td>
<td>1970</td>
<td>400</td>
<td>1 x bomb</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Land-Based Missiles</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>DF-3A CSS-2</td>
<td>40</td>
<td>1971</td>
<td>2,800</td>
<td>1 x 3.3 Mt</td>
<td>40</td>
<td></td>
<td>Two-Stage; Storable liquid</td>
</tr>
<tr>
<td>DF-4 CSS-3</td>
<td>20</td>
<td>1980</td>
<td>4,750</td>
<td>1 x 3.3 Mt</td>
<td>20</td>
<td></td>
<td>Two-Stage; Storable liquid</td>
</tr>
<tr>
<td>DF-5A CSS-4</td>
<td>20</td>
<td>1981</td>
<td>13,000</td>
<td>1 x 4-5 Mt</td>
<td>20</td>
<td></td>
<td>Two-Stage; Storable liquid</td>
</tr>
<tr>
<td>DF-21A CSS-5</td>
<td>48</td>
<td>1986</td>
<td>1,800</td>
<td>1x200-300kt</td>
<td>48</td>
<td></td>
<td>Two-stage; Solid fuel; Road mobile</td>
</tr>
<tr>
<td>DF-31 CSS-?</td>
<td>0</td>
<td>2001?</td>
<td>8,000</td>
<td>MIRV x ?</td>
<td>?</td>
<td></td>
<td>Three-stage; Solid fuel; Road mobile</td>
</tr>
<tr>
<td>DF-41 CSS-?</td>
<td>0</td>
<td>2010?</td>
<td>12,000</td>
<td>MIRV x ?</td>
<td>?</td>
<td></td>
<td>Three-stage; solid fuel; road mobile</td>
</tr>
<tr>
<td><strong>SLBM</strong></td>
<td></td>
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</tr>
<tr>
<td>Julang-1 CSS-N-3</td>
<td>12</td>
<td>1986</td>
<td>1,700</td>
<td>1x200-300kt</td>
<td>12</td>
<td></td>
<td>Two-stage; solid fuel; sea-based version of DF-21</td>
</tr>
<tr>
<td>Julang-2 CSS-N-4</td>
<td>0</td>
<td>2000?</td>
<td>8,000</td>
<td>1x200-300kt</td>
<td>?</td>
<td></td>
<td>Three-stage; solid fuel; sea-based version of DF-31</td>
</tr>
<tr>
<td><strong>Tactical weapons</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DF-15 (M-9) CSS-6</td>
<td>?</td>
<td>600</td>
<td>Nuclear capable 1 x low kt</td>
<td>600</td>
<td>Nuclear capable 1 x low kt</td>
<td>Solid-fuel, road mobile</td>
<td></td>
</tr>
<tr>
<td>DF-11 (M-11) CSS-7</td>
<td>?</td>
<td>280</td>
<td>Solid-fuel, road-mobile.</td>
<td></td>
<td>Nuclear capable 1 x low kt</td>
<td>Total Tactical warheads: ~120</td>
<td></td>
</tr>
<tr>
<td>Artillery ADMs</td>
<td>?</td>
<td></td>
<td>Low kt</td>
<td></td>
<td></td>
<td></td>
<td>Solid-fuel, road mobile</td>
</tr>
</tbody>
</table>

* Figures for bomber aircraft are for nuclear-configured versions only. Hundreds of aircraft are also deployed in non-nuclear versions. Hong-5 bombers previously had a nuclear role, but have been retired. For more than a decade, China has been developing a supersonic fighter-bomber, the Hong-7, but it will reportedly not have a nuclear role. Aircraft range is equivalent to combat radius. Assumes 150 bombs for the air force, with yields estimated between 10 Kt and 3 MT.

China's Nuclear Weapon Storage and Deployment

China has been unwilling to divulge much information about how or where its nuclear weapons are stored. This secrecy is presumably to help assure the safety and security of its arsenal, given the arsenal's limited size and China's storage methods for its nuclear weapons. China must maintain secrecy about the location of its nuclear weapons in order to ensure the survivability of its arsenal.

Many of China's warheads are located at assembly and storage facilities. Of China's deployed nuclear weapons, some ICBMs are deployed in silos, but most are kept hidden in caves and deep canyons. The following is the available information on China's nuclear weapons storage system.

Nuclear Weapon Storage, Assembly, and Research Facilities

China is believed to store some of its warheads at storage facilities that are scattered across the country. A major storage facility is believed to be the Lop Nur test site, which might contain as many as 150 tactical nuclear weapons. Chinese nuclear weapons are also probably located at a several nuclear weapon assembly facilities. Information on the specific facilities is scarce, but nuclear weapons are believed to be assembled at the Jiuquan Atomic Energy Complex in Gansu, Harbin in Heilongjiang, and Plant 821 in Sichuan. It is also likely that some warhead prototypes are built at some of China's nuclear weapon research facilities, such as the Mianyang facility.

Nuclear-Capable Bombers and Gravity Bombs

Not much is known about China's nuclear-capable bomber force. According to Norris et al., "It is believed that [China's] bomber force is assigned nuclear and conventional missions and is deployed at regular air bases and also on rotation to numerous contingency bases." It is not clear whether the nuclear-capable bombers are organized into independent units, or whether they are integrated into the same units as conventional bombers. It does appear that each major unit (up to an air division) is assigned to one air base, which is responsible for all aspects of

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25 Ibid., p. 375; Jones et al., Tracking Nuclear Proliferation, p. 65.
26 During the mid-1960s to the mid-1970s, China intentionally created duplicate facilities in order to increase the survivability of its nuclear-weapons complex during times of war. See Norris et al., Nuclear Weapons Databook, Vol. V, p. 349.
27 Ibid., p. 375.
operations, training, maintenance and repair. If China's bombers are assigned nuclear missions, one might conclude that some nuclear gravity bombs are stored at air force bases. But this has never been verified. Jack Anderson quotes a DIA report as saying that "only one national stockpile site and no regional sites have been observed in China. Thus if nuclear weapons for air delivery are deployed to air bases, they have been effectively hidden."[9]

Nuclear Missiles Deployed in Caves and Silos

China's first-generation missiles have been stored either in caves or silos. The Dong Feng-4 (DF-4), for example, is still stored in caves. The cave-storage method, however, causes significant problems in China's ability to respond quickly to nuclear attacks. The Dong Feng-4 is stored horizontally in the caves, but its skin is too thin for it to be filled with propellants in this position without causing serious body damage (even though it uses a storable liquid fuel).[10] Large, liquid-fueled missiles such as the DF-4 therefore need to be prepared inside the cave, rolled outside, then erected and filled before it can be fired.[11]

DF-5 missiles, the only missiles capable of striking the United States, are stored in silos. As of 1992, only four DF-5A missiles had been deployed in silos.[32] Although these missiles use a storable liquid fuel, they can only be kept fueled for about 24 hours because the fuel is highly corrosive and the missiles could leak.[33] The DF-5 missiles are therefore stored unfueled, with fuel storage tanks located nearby.

China's method of storing weapons in silos could also cause some problems. It is not clear that these silos have been sufficiently hardened to survive a nuclear strike. In order to make its silo-stored missiles more survivable, China reportedly built a large number of bogus silos.[34] According to a report by the Center for Defense and International Studies (CDISS), however, "only two Chinese ICBM silos have been identified, both near Luoning in Henan Province, [which is located] in central China."[35]

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[28] Ibid.
[29] Ibid.
[31] Ibid., p. 19.
[33] Ibid., p. 19.
[35] Lewis and Hua, "China's Ballistic Missile Programs," p. 25.
China’s Transition to a Mobile Ballistic Missile System

The small number of missiles in China’s arsenal, combined with its storage method for these missiles, raised concerns in China about the survivability of its arsenal in the case of a nuclear attack. In order to increase the survivability of its nuclear arsenal, China has been developing a mobile ballistic missile system since the early 1980s. Once China has completed the transition to a mobile missile system, it is not clear how or where China will deploy its missiles, but it will have the capability to deploy its missiles in a launch-ready condition, where the missiles are stored fully-fueled and with their warheads mated. Indeed, missiles using solid propellants must remain fueled during storage. In addition, if the missiles will be mobile, the warheads will need to be kept near the missiles. Since continual transportation of both the de-mated warheads and the missiles is difficult and time-consuming, it is quite possible that the warheads will be kept mated to the missiles, or will be mated in periods of increased alert.

C³I (Command, Control, Communication, and Intelligence)

Chain of Command—The Roles of the Chinese Communist Party (CCP), the Central Military Commission (CMC), and the Second Artillery

There is little question that the command-and-control structure is designed so that the CCP has the ultimate authority over the use of China’s nuclear weapons. In 1929, Mao Zedong stated that “Our principle is that the Party controls the gun and the gun shall never be allowed to

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37 The solid propellant is cast directly into the missile shell. The solid fuel actually provides some of the structural integrity of the rocket stage into which it is built.
control the Party,” and it is unlikely that this principle has changed. If a decision were made to launch China’s missiles (or to prepare them for launch), the command would probably originate in the Central Committee of the CCP Politburo. The command would then be relayed to the CMC, the association that has direct authority over all armed forces of the People’s Republic of China. The CMC would then relay the launch command to the senior leadership in the PLA.

The central command and control center for all PLA forces, including the Second Artillery, is Xishan, in the hill west of Beijing, where strategic operational orders originate. The Second Artillery is responsible for the command-and-control of China’s nuclear and conventional missile forces. A launch command would pass from Xishan to the Second Artillery headquarters and its communications regiment. The command would then be sent directly to China’s six launch bases, bypassing China’s military region commands. The launch base command centers would, in turn, communicate with their respective launch brigades. Each launch base is directly subordinate to the Second Artillery Commander in Qinghe, although they do receive support from the military regions.

Nuclear Force Doctrine: Minimal vs. Limited Deterrence

For many years, China has relied on a doctrine of “minimal deterrence.” This doctrine requires only a small number of strategic weapons to inflict unacceptable damage to a few of an enemy’s cities. Such a doctrine does not allow for a disarming first strike; rather, it requires the NWS to “ride out” a nuclear strike and then engage in a delayed retaliation. China maintained such a force doctrine until at least the late 1990s. For example, it has an official doctrine of “no

40 Kominiak et al., The “Command and Control” Philosophy of the Communist Party of China, pp. 10–11.
41 Although there is very little open-source information on the chain of command in China’s navy or air force, it is possible that they also have limited nuclear roles. Nevertheless, China primarily relies on the Second Artillery for its nuclear forces because China’s air force is antiquated and China only possesses one ballistic missile submarine, which reportedly has constant operational difficulties. See Bates Gill and James Mulvenon, “The Chinese Strategic Rocket Forces: Transition to Credible Deterrence,” paper presented at China and Weapons of Mass Destruction: Implications for the United States, conference sponsored by the National Intelligence Council and Federal Research Division, November 5, 1999, <http://www.cia.gov/nic/nic_publications/conference_reports/china_and_weapons_of_mass_destruction.html>, pp. 6, 20.
42 Ibid., p. 20.
first use" (NFU) of nuclear weapons and a small ICBM force stored that cannot be readied and fired rapidly. However, in recent years, China has appeared to be evolving toward a force doctrine of "limited deterrence." A limited deterrence doctrine calls for some counterforce and warfighting elements, with intended targets including enemy missile bases, C3I centers, and strategic warning assets. Chinese strategic analysts argue that limited deterrence requires a greater number of smaller, more accurate, survivable, penetrable ICBMs and SLBMs; a ballistic missile defense capability to protect its limited deterrent force; space-based early-warning and command-and-control systems, and anti-satellite assets to hit enemy military satellites. Some Chinese analysts have also argued that China's first response must be immediate and extremely rapid. As Iain Johnston points out, while this response would still be a reaction to an aggressive action taken by the enemy (and therefore probably still in accordance with China's doctrine of NFU), it is not at all clear that China's forces should wait until after this initial action is complete. "In other words, there are intriguing hints of interest in launch-on-warning or launch-under-attack." Until recently, China's capabilities fell far short of what would be required by a doctrine of limited deterrence. But recent advances in China's C3I have brought China much closer to this goal.

**China's C3I Modernization**

*Improved Ballistic Missile Capabilities*

China's current generation of missiles does not allow for anything approaching limited deterrence. These missiles are fairly inaccurate, which limits their utility in precision strikes of...
hardened targets, and they are stored unfueled with their warheads unmated, which prevents rapid response and survivability. The newer generation of missiles solves many of these problems, however. For example, according to the U.S. Pentagon, China is using the Global Positioning System to make “significant improvements” in the accuracy of its newer missiles. In addition, if the missiles are stored with their warheads mated, they could allow for rapid-response. Indeed, most sources indicate that the launch times for the DF-31 and DF-41 would be under 15 minutes and under 5 minutes, respectively.50 The number of strategic missiles in China’s arsenal would prevent a limited deterrent posture for some time, however. Nevertheless, China is reportedly planning to increase significantly the number of missiles in its arsenal, especially if the United States deploys NMD.51

Upgrades of China’s Command System

C3I modernization has been one of China’s top priorities since 1979, and China has made significant improvements in this area. In some cases, the “breakthroughs” reported suggest that the past level of command-and-control structures was not particularly advanced. For example, the official People’s Liberation Army Daily in early 1998 noted that the SAC “after three years of arduous work” developed a new digital microwave communications system, which now allows for secure “all-weather” communications for missile launch. “With the new system,” the article notes, “the Second Artillery will no longer be affected by natural conditions such as weather.”52

Nevertheless, according to a 1998 report by the Department of Defense, China’s command-and-control facilities are located in an extensive network of hardened, underground shelters that would be very resistant to attack. The communication system is carried by a number of redundant transmission systems, and has been determined to be “survivable, secure,


flexible, mobile, and less vulnerable to exploitation, destruction or electronic attack." The DoD report concludes that the command-and-control systems are capable of supporting military operations within China and would probably survive attempts at decapitation.

Intelligence: Improving Early-Warning and Satellite Capabilities

The PLA has long suffered from antiquated air defenses and intelligence networks. Specifically, the PLA Air Force (PLAAF) has lacked decent early-warning radars, early-warning satellites, and automated intelligence handling and transmission facilities. Since the Gulf War, however, Chinese policymakers have placed a high priority on upgrading their overall air defense capability in order to protect strategically critical points. A comprehensive air defense network is reportedly being designed to counter air and missile attacks. The network is composed of numerous segments, including early-warning radar and satellites, rapid data processing and command centers, air defense weapons, and offensive counter-air and counter-space weapons. China is reportedly close to achieving the capability to develop early-warning systems. As Mark Stokes notes, "China has a well-established technology base in infrared sensors, which, when placed on satellites, can detect a missile almost immediately after launch by detecting the infrared radiation from its engine motor plume. Technical writings indicate the space industry is working to master specific technologies associated with missile early warning satellites."

In 1975, China dismissed the option of a launch-on-warning system because it was unable to build a reliable early warning system. Were China to achieve a reliable early-warning system, it might adopt a doctrine of limited deterrence, possibly including a policy of launch-on-warning. China is believed to be much more likely do adopt such doctrines if the United States develops and deploys NMD.
Use-Control Devices and "Negative Controls"

There is evidence that China's nuclear weapons lack sophisticated use-control devices to ensure central controls. For example, China's weapons reportedly lacked PALs in 1987, and it is not believed that this situation has changed during the intervening years. Although there have been reports that China has improved its command-and-control system in recent years, these improvements appear to have been primarily in communications systems. As Bates Gill and James Mulvenon note, these changes improve the leadership's "positive control" over its nuclear forces by increasing the survivability of the missile forces and command systems. They do not appear to improve China's "negative control," or the element of command and control that prevents the accidental or unauthorized use of the nuclear weapons. Instead, China reportedly maintains negative controls through guard forces, separate storage of warheads and missiles, and procedures such as the two-man rule.

The Risks of Accidental Use of Chinese Nuclear Weapons

Given China's current missile systems and deployment procedures, it is considered unlikely that China will accidentally launch a nuclear ballistic missile. According to Robert D.
Walpole, U.S. National Intelligence Officer for Strategic and Nuclear Programs, an unauthorized or accidental launch of a Chinese nuclear missile is highly unlikely, as long as current security procedures and systems are in place, because China keeps its missiles unfueled and without warheads mated. In fact, under the best circumstances, it would take China several hours to prepare these unassembled missiles for launch. While its missiles are stored in this condition (i.e., during peacetime), there is virtually no chance of any typical accidental-launch scenario occurring.

Of course, the fact that China keeps most of its missiles unfueled and warheads unmated does not completely remove any chance of an accidental launch. If China found itself in a situation where it decided to bring its missiles to a launch-ready condition, it might need to assemble them in an extreme hurry. Unless China had rigorously trained its personnel to assemble the weapons under these conditions, they might be more likely to make mistakes, possibly leading to an accidental launch. It is not clear whether China has in fact trained its personnel to act under such crisis situations, but we do know that China has not done the extensive training and tests that the United States and Russia have. Thus, the chance of China's accidentally launching its missiles is quite low during peacetime, but it might in fact be significantly higher during crisis situations.

Although China's mobile missile system could reduce the chance of a preemptive strike, it could also introduce new risks of accidental launch. As we have seen, it is quite possible that the warheads will be kept mated to the missiles, or will be mated in periods of increased alert. If China's missiles were stored in this launch-ready condition, the risks of accidental launches could increase significantly. Indeed, one must recall that China already has some road-mobile tactical missiles. If the warheads are continuously mated to these tactical missiles, then there might be a chance that China could accidentally launch a nuclear missile against a neighbor (such as Taiwan).

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67 For a similar argument, especially related to "opaque" proliferating countries, see Feaver, "Neooptimists and the Enduring Problem of Nuclear Proliferation," p. 115.
68 Although Gill and Mulvenon argue that China might not be pushing as strongly for rapid-response capabilities in
The Risks of Unauthorized Use of Chinese Nuclear Weapons

The chance of an unauthorized use of China's nuclear weapons appears significantly greater than the chance of an accidental use. China's current system of command and control relies heavily on the presence of the "three G's": guards, gates, and guns. There is, however, a significant weakness in a command-and-control system that relies heavily on guard forces: if there is a breakdown in the chain of command, the guards might follow the orders of someone who is disobeying the commands of the central authorities.

Because Chinese weapons appear to lack sophisticated use-control devices equivalent to U.S. PALs, China would not have any technological means of ensuring control over its nuclear arsenal during a domestic political crisis. In these cases, the chance of an unauthorized use of nuclear weapons could be unacceptably high. It is this weakness in particular that led Terry Hawkins, Director of the Nonproliferation and International Security Division of Los Alamos National Laboratory, to say, "China's command and control over its nuclear weapons possibly is not as good as we'd like it to be."69 According to Robert Walpole, the unauthorized use of Chinese nuclear weapons is highly unlikely "as long as current security procedures and systems are in place."70 But in times of political crisis, the command-and-control system in China would not necessarily stay in place. Indeed, there is reason to suspect that China's command-and-control structure has demonstrated significant weaknesses during more than one political crisis.71

The Cultural Revolution

The Cultural Revolution was a time of extreme political turmoil for China. As the entire country collapsed into chaos, political purges, uprisings, revolts, and riots were commonplace. Although Nie Rongzhen, head of China's overall strategic weapons program, managed to isolate the nuclear weapons program from this revolutionary frenzy for a time, it was impossible to hold off the effects of the political crisis forever. During the Cultural Revolution, there were several incidents that involved China's nuclear weapons.

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71 There is a great deal of overlap between the protection against unauthorized use and MPC&A. See the discussion of China's MPC&A in part three of this paper.
October 1966: Red Guards Conducted an “Unauthorized” Nuclear-Armed Missile Test

In 1966, at the peak of the Cultural Revolution, the Second Artillery launched an armed nuclear warhead over Chinese population centers, apparently contrary to the orders of Nie Rongzhen.72 Evan Feigenbaum reports this incident in his Ph.D. dissertation:

In part because strategic weapons tests had powerful patriotic and ideological appeal, weapons testing became increasingly identified with mobilizational fanaticism when the Cultural Revolution broke out in military industry. Red Guards in Beijing and rebel factions among the workers on the test bases adopted weapons tests as a cause célèbre of their movement, explicitly suggesting a “bond between the creative force of Mao’s radicalism and the force of the [atomic] bomb” (Lewis and Xue, 1988a, p. 202). When the Second Artillery Corps decided to test a DF-2 missile on October 27, 1966 by launching it, armed with a live warhead, over population centers against a ground zero in Xinjiang, Nie [head of NDSTC, which had de facto control over the Second and Seventh Ministry systems]—powerless to halt the test—attempted to at least control its potentially disastrous effects by taking personal charge of safety procedures. On the 25th, he flew to the Shuangchengzi launch base (Base 20) to demand briefings on safety procedure. After the test, a relieved Nie flew to the impact zone to assess the missile’s accuracy and to demonstrate his authority.73

Although the missile hit its target without any mishap, this case demonstrates the lack of a resilient command-and-control structure in China at that time. Granted, this was only an unauthorized test launch of an armed nuclear missile; it was not a launch against another country. But this test launch shows us two things. First, if the soldiers in the Second Artillery who decided to launch the missile had decided—in a similar revolutionary or patriotic frenzy—to launch the nuclear missiles against another country, they could have. It is clear that in 1966 China had few—if any—reliable controls against the unauthorized use of its nuclear weapons. Second, this incident shows that the people who have control over nuclear weapons do not always make rational decisions about the use of these weapons. This was reportedly only the second test launch of any DF-2, and the first test of a DF-2 missile armed with a nuclear warhead. And it was only China’s fourth nuclear test altogether.74 The Second Artillery took a very great risk when it launched this missile over China’s own population centers. In his memoirs, Nie Rongzhen emphasized the extreme danger of this test: “if by any chance the

nuclear warhead exploded prematurely, fell after it was launched, or went beyond the designated target area, the consequences would be too ghastly to contemplate.""}75

January 1967: Mao Yuanxin led attack on Lop Nur

In January 1967, staff members of the Nuclear Weapons Test Base defied orders and invited radicals from the Red Rebellious Corps from the Harbin Military Engineering Institute (HMEI) to Xinjiang to engage in revolutionary activities and attack "bourgeois" personnel. Mao Yuanxin (Mao Zedong’s nephew) led a group of radicals on a 4,000 km trip to attack the Lop Nur test base. By the time they arrived, Nie Rongzhen had prepared the base’s defenses and had the radicals arrested as they attacked.76

December 1967: Regional Military Commander Threatened to take over Lop Nur Test Site.

In 1967 General Wang En-Mao, military commander of the Chinese province of Xinjiang, reportedly threatened to take over the Lop Nur nuclear weapons testing site during a dispute with Mao Zedong. Since Lop Nur is probably a major nuclear weapons storage site, this threat also entailed seizing control over the nuclear weapons stored at the site. Although this dispute was resolved peacefully and the threat never carried out, Wang probably would have been able to seize independent control over the nuclear weapons if he had wanted to.77

1971: The Lin Biao Affair

Near the end of the Cultural Revolution, there was a growing disagreement between Mao Zedong and his then-designated successor, Defense Minister Lin Biao, over the political role of the People’s Liberation Army (PLA). Because of this disagreement, Mao eventually removed Lin from his position as successor. As it was becoming clear that he was losing Mao’s favor, however, Lin increasingly turned to his other main power base—the PLA. These political events

75 Nie Rongzhen, quoted in Lewis and Xue, China Builds the Bomb, p. 203.
76 Lewis and Xue, China Builds the Bomb, pp. 203–204; Feigenbaum, The Military Transforms China, p. 220.
came to a head when Lin, Ch’en Po-ta (another prominent political figure), and five top-ranking military officials challenged Mao, first openly at the Second Plenum of the Ninth Central Committee, and then clandestinely by plotting a coup d’etat to remove Mao from power. By September 1971, however, it became clear that the coup plans had failed, after Mao managed to gain assurances of loyalty from regional military leaders in preparation for a final showdown with Lin. When Lin learned of this, he reportedly attempted to flee the country by flying to the Soviet Union. He never made it. Lin died, along with his wife and son, when their plane crashed in Mongolia (either because it was shot down or because it ran out of gas).78

The Lin Biao affair was above all “a struggle between a Mao-led civilian party and a Lin-led Army for control of China’s political system.”79 Both the Lin Biao affair and the subsequent purges resulting from it created deep tensions between the PLA and the governing party.80 This struggle is especially troubling because the PLA had—and still has—custody over China’s nuclear weapons, and because these weapons did not contain PALs. As Dan Caldwell suggests, this affair must have raised the question in Chinese leaders’ minds about the necessity for use-control devices on nuclear weapons.81 In fact, it appears that the Chinese discussed PAL technologies with the United States some time after the Lin Biao affair.82 It is reasonable to conclude that they probably had in mind some of the risks that arose during the Lin Biao affair.

The Tiananmen Square Crisis

At the time of the Tiananmen Square Crisis, there was a great deal of speculation about a possible break-down in Chinese command arrangements that would then have spurred a loss of central control over China’s nuclear forces.83 Since there was not much evidence in the public domain at the time to confirm these speculations, however, it was generally concluded that the

80 Security Conditions in China, pp. 3–4. Indeed, the air force was forced to stand down for two months as a result of the Lin Biao affair (ibid., p. 4).
82 Ibid., p. 231.
Chinese command structure was probably more resilient than previously believed. Indeed, in China’s command and control over its nuclear weapons during the Tiananmen Square Crisis. According to a report in the *Washington Post*, China expressed interest in U.S. PAL technology in 1994 because during the Tiananmen Square crisis Beijing’s leaders had feared their army might split over the decision to crush student protests, causing the central government to lose control of its nuclear arsenal. American PALs, the Chinese said, would reduce any such risk in the future. It is therefore worthwhile to examine carefully what might have happened during the Tiananmen Square crisis because it can shed light on the consequences of any continuing weaknesses in China’s command-and-control structure.

The weakness in China’s command-and-control structure during the Tiananmen Square crisis appears to have been caused principally by a significant weakness in the central government’s authority over the PLA, combined with an apparent lack of technical means of authentication and central control over China’s nuclear forces.

There is strong evidence of factional conflict in the PLA. During the crisis, a number of military units were quite reluctant to use force against the students. A major factor in determining whether or not a given military unit in the PLA remained loyal to the central government was personal loyalty to high-ranking military leaders. In particular, a number of high-ranking military officers signed publicly-distributed letters opposing the use of force. It appears that many units of the PLA were more loyal to these officials than to the central government, especially when the officials had had some personal connection with the units.

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84 Ibid., p. 164.
85 Coll and Ottaway, “Will the United States, Russia and China be Nuclear Partners or Rivals in the 21st Century?,” p. A01. On several occasions, Chinese officials admitted to Danny Stillman, a former intelligence analyst at Los Alamos National Laboratory, that “splits in their military during the Tiananmen crisis brought home the potential danger of unauthorized control of nuclear weapons, and they wanted the United States to provide older PAL technology that would make Chinese bombs safer but not jeopardize U.S. bomb security.” See Coll, “The Man Inside China’s Bomb Labs,” p. A01. The author has also verified the accuracy of these reports in several interviews with high-level U.S. government officials, conducted from 1998 to 2001.
86 For example, Qin Jiwei, the Minister of Defense at the time, was known to have opposed using force against the students. During the crackdown, Zhou Yibing, Qin’s long-time deputy and the commander of the Beijing Military Region, appeared to side with Qin. As a result, Zhou’s troops also appeared reluctant use of force against the students. In another case, Hong Xuezhi, a former Director of the PLA’s General Logistics Department also opposed the use of force, and the personnel of the Logistics Department appeared to side with Hong against the government. For a summary of these events, see June Teufel Dreyer, “The Role of the PLA in China’s Political Struggle,” in Richard H. Yang, ed., *The PLA and Tiananmen Crisis*, SCPS Papers, no. 1 (Taiwan: The Sun Yat-Sen Center for
is likely that at least some members of the Second Artillery were influenced by personal relationships, just as the rest of the PLA was. Indeed, a number of high-ranking military officials who were influential with the Second Artillery opposed the use of force against the students.

One of these influential military figures was the Minister of Defense, Qin Jiwei. After the imposition of martial law in Beijing, approximately three hundred military officers signed a letter opposing the use of force against the protestors, including Qin Jiwei.87 In addition, the political stances taken by Nie Rongzhen and Zhang Aiping, two prominent (though retired) military officials and heroes of China’s nuclear weapons program may have influenced members of the Second Artillery. Both of these men publicly opposed the use of force against the students.88 Nie Rongzhen had been the head of the strategic weapons program during China’s push to build the bomb.89 Zhang Aiping was an ex-minister of defense90 and had overseen China’s first test of its atomic bomb. Both of these men were public heroes, and were probably especially revered in military units such as the Second Artillery that were most directly affected by their past work.

Ultimately, if there were weaknesses in China’s chain of command at the time of the crisis, the loyalty of the Second Artillery to the central government must have been in doubt, since it physically controls almost all of China’s nuclear weapons.91 Since Chinese nuclear

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Policy Studies, National Sun Yat-Sen University, p. 4.


89 Lewis and Xue, China Builds the Bomb, p. 247.


91 Some evidence for this is that in March 1990 General Li Xuge (Second Artillery commander at the time) wrote an article in China’s Liberation Army Daily that further political and ideological work was necessary to ensure the troops in the Second Artillery are “always qualified politically” (quoted in George Kominiak, Jane Eisenhauer,
weapons did not contain PALS (or equivalent use-control devices) during the crisis, a revolt by the Second Artillery would probably have constituted a loss of central control over China’s nuclear weapons.

Possibilities of Future Political Instability in China

The above cases demonstrate how political instability can weaken China’s nuclear controls. Nor is it clear that China will avoid severe political instability in the future. China has been changing fundamentally in a number of ways in recent years. These changes have been sources of significant instability and it is not yet clear that the regime will survive these changes. Indeed, it appears that the Chinese Communist Party (CCP) is rapidly losing influence in China. This is partly due to the liberalization of China’s economy, partly due to the CCP’s increasing inability to solve many of China’s internal difficulties such as the separatist movements and the pressures of liberalization, and partly due to the large dissatisfaction in the populace with widespread government corruption. After years of being denied by the government and the government-controlled press, these problems have become severe enough that the CCP has recently been forced to admit them. According to a June 2, 2001 article in the New York Times, “A startlingly frank new report from the Communist Party’s inner sanctum describes a spreading pattern of ‘collective protests and group incidents’ arising from economic, ethnic and religious conflicts in China and says relations between party officials and the masses are ‘tense, with conflicts on the rise.’”92 The following sections discuss these sources of instability in greater detail.

Economic changes and political stagnation

The most fundamental changes have resulted from China’s transition to an open economy. With a sustained yearly growth rate of nearly 8%, China’s economy has grown dramatically in the last decade. China’s expected entry into the World Trade Organization (WTO) would guarantee that China’s economy would continue to open up in the future.93 But these economic changes, and in particular, China’s entry into the WTO will create severe shocks


to the political system in both the short term and the long term. As Minxin Pei, a senior associate at the Carnegie Endowment for International Peace, has argued, "in both the short and long term, China's entry into the WTO—and the radical economic reforms likely to accompany it—will generate powerful shocks to the country's existing political system...It remains highly uncertain, however, whether the Chinese regime is resilient enough to withstand such shocks."  

China's economic restructuring has only benefited a small, highly-educated elite and has actually worsened conditions for workers in traditional industries and rural farmers. The worsening economic conditions in these two groups, combined with increasing frustration with widespread corruption in the CCP, have caused these groups to become immense reservoirs of social discontent. In recent years, there have been an increasing number of riots over government corruption, excessive taxation, and the CCP's inability to ease the economic hardships among industrial workers and rural farmers. According to some reports, there were over 100,000 protests in China in 1999, many of which led to violent clashes. The following are just a few recent examples of such incidents:

- In late 1998, the people of Shao village in southern Hebei rioted for the right to vote and more than 700 riot police surrounded the village.
- On October 18, 1999, over 2000 protesters took over a Sichuan railway station in protest over government handling of funds invested in illegal companies.
- In February 2000, tens of thousands of workers erupted in a violent protest at China's largest nonferrous metal mine, burning cars and holding police at bay for several days. The workers were protecting against what they said was an unfair and corrupt handling of the mine's bankruptcy.
- In August 2000, up to 20,000 farmers rioted for five days in the Jiangxi province in southern China, with some attacking government buildings and looting officials' homes in protest over government fees and taxes.
- On April 20, 2001, more than 600 police and paramilitary troops stormed the village of Yuntang in the Jiangxi Province, which was rebelling against rising taxes and official corruption.

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95 Ibid., p. 4.
96 This estimate was issued by the Hong Kong-Based Information Center of Human Rights and Democracy, reported in "Drought Fuels Violence in China," Washington Post, July 16, 2000. Official Labor Ministry statistics, which were reportedly passed to a Western diplomat, indicated that there were 120,000 labor disputes in 1999—14 times the number of disputes in 1992 (reported in John Pomfret, "Chinese Workers Are Showing Disenchantment," Washington Post, April 23, 2000, p. A23).
The growing discrepancy between the rapid economic reforms and the lack of political reforms is a major potential source of political upheavals and possibly the collapse of the regime. According to Hua Di, "the real threat to the PRC's current regime comes not from foreign military intervention...but from the Chinese people's pervasive dissatisfaction with the regime's corruption." Hua concludes that "unless a political reform is launched and succeeds, in which the current regime in China takes initiative to change itself from a one-party dictatorship to a multi-party democracy, the corruption will not end but the regime will be finished."

Increasing Regionalism and Separatist Movements

There are also numerous reports of increasing regionalism and separatist movements that could threaten to break China apart. For example, there are large economic disparities between the rich, southeastern provinces and poor, western provinces. Chinese leaders are reportedly worried that the southeastern provinces will some day refuse to finance the poor, western provinces and attempt to leave China. But the western provinces are even more likely to want to break away from China. There are several separatist movements within China, most notably in Tibet and the western province of Xinjiang. The separatist movement in Xinjiang has been particularly violent, where the predominantly Islamic Uighur population reportedly receive arms

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98 Hua, "China's Security Dilemma," p. 3.
99 Ibid., p. 3. For a similar assessment, see Minxin Pei, "Will China Become Another Indonesia?," Foreign Policy, no. 116 (Fall 1999), pp. 94–109.
and training in places like Afghanistan and Pakistan, then return to oppose Beijing. Although Beijing has engaged in severe crackdowns on these movements—Western-based monitoring groups have recorded more than 200 death sentences and 200 executions of Xinjiang separatists since 1997—it has been surprisingly unsuccessful in quelling the unrest.\(^2\)

There is also reportedly ethnic unrest in Inner Mongolia that could develop into a full-fledged separatist movement. China is quite worried that if one area were to achieve independence, the other areas would increase their efforts to secede. For example, the sheer resilience of the Xinjiang separatist movement has reportedly helped encourage Tibetans and Mongolians in their struggles against the central government.\(^3\) This is reportedly a major reason why Beijing is so determined to prevent Taiwan’s separation from mainland China.\(^4\)

**Conclusions about Unauthorized Use**

The events during the Cultural Revolution and the Tiananmen Square Crisis suggest a troubling weakness in China’s command and control over its nuclear weapons. China’s command-and-control structure seems to work well enough under normal, peaceful circumstances, but has proven to be vulnerable in times of acute political crisis. During these times, the risk of unauthorized use of Chinese nuclear weapons has been unacceptably high. This fact seems especially frightening, since China has experienced a great deal of political turmoil since its revolutionary beginning in 1949. These major political crises include the Great Leap Forward in 1958–60, the Cultural Revolution from 1966–71, Lin Biao’s attempted coup d’état in 1971, and the Tiananmen Square Crisis in 1989. And, one must recall, a number of these incidents occurred while China possessed nuclear weapons.


\(^3\) George, “Islamic Unrest,” p. 2.

Moreover, as we have seen, there are continuing possibilities of serious economic, political, and social upheavals in China in the future. Given China's current system of nuclear controls, this political instability could have very severe consequences. According to Jones et al., "the possibilities run the spectrum from a breakup of China into multiple states, the breakdown of central authority and the rise of regional warlords, or a steady deterioration of central authority that would increase the opportunity for theft and smuggling of nuclear materials or weapons."105

The Risks of Inadvertent Use

The current risks of inadvertent use of Chinese nuclear weapons are probably fairly low because China keeps its missiles unfueled and warheads unmated. Because China has only a limited ability to respond rapidly, it would be much more likely to "ride out" a nuclear strike and hope that enough of its nuclear weapons survive to allow it to retaliate. Nevertheless, because it is not at all certain that any of China's strategic nuclear weapons would survive a first strike, it is quite possible that China would prepare its weapons for launch during a crisis.

If China were to assemble its nuclear weapons during a crisis, however, an adversary could misinterpret these actions as an indication that China was actually planning to launch its weapons. Given the long preparation times for China's strategic missiles and the excellent reconnaissance satellites of potential enemies such as the United States, China's enemies might be able to learn that it was assembling its weapons and the locations of these weapons.106 This might cause an enemy to panic and engage in a preemptive nuclear strike before China's missiles were ready to be fired.107

Some scholars have also expressed concern that the preparation of China's weapons would create a "use them or lose them" scenario. Because China's current generation of long-range missiles use a highly-corrosive liquid fuel, they need to be fired within 24 hours after they are fueled. And since it is virtually impossible to take the fuel out of the missiles again without

106 The warheads could probably be assembled inside the cave, but they would need to be erected and fueled outside.
107 The Chinese have reportedly been quite concerned that U.S. spy satellites would enable the United States to identify where the assembly of missiles is taking place. See Lewis and Hua, "China's Ballistic Missile Programs," p. 23.
damaging the missiles, any deterrent effect China has from its nuclear weapons would be eliminated within 24 hours after China fueled its weapons. These conditions could create very strong pressures for China to use its weapons once they are fueled. Of course, these pressures would be balanced by the very strong pressures for China not to launch its weapons because of the consequences of a nuclear retaliation. Perhaps a more serious “use them or lose them” scenario would arise due to the vulnerability of China’s nuclear weapons to a disarming first strike by an adversary such as the United States. If, during a crisis, China had prepared its weapons for launch and believed that a U.S. attack was imminent, it might decide to use its weapons first, thereby ensuring that its weapons would not be destroyed.

Moreover, the risks of inadvertent use would increase significantly if China were to move to a force doctrine of “limited deterrence.” As we have seen, such a doctrine would require advanced early-warning systems and some counterforce capabilities. Some of China’s military analysts have argued that China should develop rapid-response capabilities and even a policy of launch-on-warning. If China does move to such a system, the risks of inadvertent war could become quite high, especially during crises. Because the decision to use the nuclear weapons would need to be made very rapidly, there would be much higher risks of panic-launches and launches due to misinformation or false alarms.

Part II: China’s MPC&A

Current Fissile Materials Stockpiles

Although China is not believed at present to be producing fissile materials for weapons, it is believed to have a fairly large stockpile of weapon-usable fissile materials. According to most recent unclassified estimates, China is believed to have accumulated as much as 4 metric tons of plutonium (Pu) and 23 metric tons of highly enriched uranium (HEU) by the end of 1994.

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109 Such an action would obviously require China to violate its declared doctrine of no first use, but given the limited survivability of its current nuclear forces, China might nevertheless decide that such a violation would be justified. Indeed, as we have seen, Iain Johnston has discovered documents by Chinese military analysts calling for a first strike under some circumstances. See Johnston, “China’s New ‘Old Thinking’,” pp. 22–23.
111 Jones et al., Tracking Nuclear Proliferation, p. 54; David Albright, Frans Berkhout and William Walker,
China's fissile materials are stored at a number of nuclear facilities across the country. The facilities range from uranium enrichment plants, to plutonium production reactors, to research centers. Fissile materials are stored at both civilian and military nuclear facilities. Historically, the same facilities were used for both civilian and military programs, but China has recently begun to convert large sections of its nuclear complex to strictly civilian use.\(^\text{112}\) (See Table 4.2 for a list of the Chinese facilities believed to contain fissile materials.)

**Chinese Agencies that Have Authority over Fissile Materials**

It is difficult to determine which agencies have responsibility for the protection of fissile materials. There are several reasons for this. First, China has not made public much information about its nuclear industry. Second, China recently restructured its nuclear bureaucracies, and the dust has not yet settled. And finally, there are sometimes deliberately overlapping lines of authority to ensure additional bureaucratic control from the top. Nevertheless, the following are the agencies that are believed to have responsibility for fissile material controls.

Before China restructured its nuclear industry in 1998, the China National Nuclear Corporation (CNNC) was responsible for the control of nuclear materials for the whole country. Within the CNNC, the National Office of Nuclear Material Control was responsible for the implementation aspects of MPC&A.\(^\text{113}\) The China Academy of Engineering Physics (CAEP) also apparently had some responsibility for production, storage, and control of fissile materials intended for military purposes.\(^\text{114}\) After the restructuring, the responsibility for MPC&A for all fissile materials was given to the China Atomic Energy Agency (CAEA). Within the CAEA, the Bureau of Nuclear Material Control is the main institution that regulates fissile materials.\(^\text{115}\)

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\(^{114}\) *Foreign Trip Report*, Lawrence Livermore National Laboratory, Sandia National Laboratories, Los Alamos National Laboratory; Beijing, China; June 23--July 2, 1995, pp. 5--6.

\(^{115}\) Wen Hsu, Distinguished Member of the Technical Staff at Sandia National Laboratory, telephone conversation
Table 4.2: Chinese Facilities believed to contain Special Nuclear Materials

<table>
<thead>
<tr>
<th>Name/Location of Facility</th>
<th>Type/Status</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nuclear Weapons Complex</strong></td>
<td>Archive on nuclear explosions, warfare, and weapons research and design; associated with testing at Lop Nur.</td>
</tr>
<tr>
<td>Jiuquan Atomic Energy Complex (Plant 404), Subei, Gansu</td>
<td>Fabrication of fissile materials into bomb cores, and final weapons assembly.</td>
</tr>
<tr>
<td>Lop Nur Nuclear Weapons Test Base, Xingjiang</td>
<td>Nuclear weapons test site and possible nuclear weapons stockpile.</td>
</tr>
<tr>
<td>Chinese Academy of Engineering Physics (CAEP), Mianyang, Sichuan</td>
<td>Nuclear weapons research, design, and technology complex; called the &quot;Los Alamos of China,&quot; 11 institutes, 8 located in Mianyang.</td>
</tr>
<tr>
<td>Institute of Applied Physics and Computational Mathematics, Beijing</td>
<td>Conducts research on nuclear warhead design computations for CAEP.</td>
</tr>
<tr>
<td>Harbin, Heilongjiang</td>
<td>Possible warhead assembly and production site.</td>
</tr>
<tr>
<td>Plant 821, Guangyuan, Sichuan</td>
<td>Nuclear weapon assembly facility.</td>
</tr>
</tbody>
</table>

**Plutonium Production Reactors**

<table>
<thead>
<tr>
<th>Name/Location of Facility</th>
<th>Type/Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant 821, Guangyuan, Sichuan</td>
<td>LWGR, nat. U. 1,000 MW; operational. Largest plutonium producing reactor in China.</td>
</tr>
<tr>
<td>Jiuquan Atomic Energy Complex (Plant 404), Subei, Gansu</td>
<td>LWGR, nat. U. 400–500 MW; operational.</td>
</tr>
</tbody>
</table>

**Research Reactors**

<table>
<thead>
<tr>
<th>Name/Location of Facility</th>
<th>Type/Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>HFETR Nuclear Power Institute of China, Chengdu, Sichuan</td>
<td>Tank. LW: HEU (90%), 125 MW; operational.</td>
</tr>
<tr>
<td>HFETR critical, Nuclear Power Institute of China, Chengdu, Sichuan</td>
<td>Critical assembly. LW: HEU (90%), 0 MW; operational.</td>
</tr>
<tr>
<td>MTR, Nuclear Power Institute of China, Chengdu, Sichuan</td>
<td>Pool. LW: HEU (90%), 5 MW; operational.</td>
</tr>
<tr>
<td>MNSR IAE, China Institute for Atomic Energy, Tuoli, near Beijing</td>
<td>Tank in pool. LW: HEU (90%), .027 MW; operational.</td>
</tr>
<tr>
<td>MNSR-SD, Shandong Geology Bureau, Jinan, Shandong</td>
<td>Tank in pool. LW: HEU (90%), .027 MW; operational.</td>
</tr>
<tr>
<td>MNSR-SZ, Shenzhen University, Guangdong</td>
<td>Tank in pool. LW: HEU (90%), .027 MW; operational.</td>
</tr>
<tr>
<td>Zero Power Fast Critical Reactor, Southwest Research Institute, Chengdu, Sichuan</td>
<td>Critical fast: HEU (90%), 0 MW; operational.</td>
</tr>
<tr>
<td>HWR-II, China Institute for Atomic Energy, Tuoli, near Beijing</td>
<td>Heavy water: LEU (3%), 15 MW; operational. Under IAEA Safeguards. (Does not produce weapons-usable fissile materials.)</td>
</tr>
<tr>
<td>SPR IAE, China Institute for Atomic Energy, Tuoli, near Beijing</td>
<td>Pool. LW: LEU (10%), 3.7 MW; operational. (Does not produce weapons-usable fissile materials.)</td>
</tr>
<tr>
<td>SPRR-300, Southwest Research Institute, Chengdu, Sichuan</td>
<td>LW: LEU (10%), 3.7 MW; operational. (Does not produce weapons-usable fissile materials.)</td>
</tr>
<tr>
<td>Tsingua Pool, Institute of Nuclear Energy Technology, Tsingua University, Beijing</td>
<td>Pool, two cores, LW: LEU (10%), 2.8 MW; operational. (Does not produce weapons-usable fissile materials.)</td>
</tr>
<tr>
<td>PPR Pulsing Reactor, Nuclear Power Institute of China, Chengdu, Sichuan</td>
<td>Pool. HEU (25%), 1 MW; operational.</td>
</tr>
</tbody>
</table>

Table 4.2 continued on following page.

### Table 4.2 continued

<table>
<thead>
<tr>
<th>Name/Location of Facility</th>
<th>Type/Status</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Uranium Enrichment</strong></td>
<td></td>
</tr>
<tr>
<td>Heping Uranium Enrichment Plant, Heping, Sichuan</td>
<td>Gaseous diffusion plant: estimated to produce 750–2950 kg HEU/year; operational.</td>
</tr>
<tr>
<td>Lanzhou Nuclear Fuel Complex, Lanzhou, Gansu</td>
<td>Gaseous diffusion plant: estimated to produce at least 150–330 kg HEU/year; operational.</td>
</tr>
<tr>
<td>Lanzhou Nuclear Fuel Complex, Lanzhou, Gansu</td>
<td>Gaseous diffusion plant: new cascade under construction, for LEU export. (Will not produce weapons-usable fissile materials.)</td>
</tr>
<tr>
<td>China Institute of Atomic Energy, Tuoli, near Beijing</td>
<td>Laboratory-scale gaseous diffusion: developed enrichment process later installed at Lanzhou.</td>
</tr>
<tr>
<td>Russian-supplied centrifuge enrichment plant, Chengdu, Sichuan</td>
<td>Large-scale centrifuge enrichment facility; under construction; capacity 200,000 SWU/yr.</td>
</tr>
</tbody>
</table>

**Plutonium Reprocessing**

<table>
<thead>
<tr>
<th>Name/Location of Facility</th>
<th>Type/Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jiuquan Atomic Energy Complex (Plant 404), Subei, Gansu</td>
<td>Large-scale reprocessing plant, capacity: 300–400 kg Pu/yr. and pilot reprocessing plant (both use PUREX method); and Nuclear Fuel Processing Plant for refining plutonium into weapons-useable metals.</td>
</tr>
<tr>
<td>Plant 821, Guangyuan, Sichuan</td>
<td>China's largest plutonium separation facility, capacity: 300–400 kg Pu/yr.</td>
</tr>
<tr>
<td>Nuclear Fuel Component Plant (Plant 812), Yibin, Sichuan</td>
<td>Plutonium fuel rod fabrication, and plutonium production and processing for nuclear weapons; operational.</td>
</tr>
<tr>
<td>Lanzhou Nuclear Fuel Complex, Lanzhou, Gansu</td>
<td>Pilot-spent fuel reprocessing plant, nominal capacity of 100 kg heavy metal per day; under construction, completion in 2000.</td>
</tr>
</tbody>
</table>

**Uranium Processing**

<table>
<thead>
<tr>
<th>Name/Location of Facility</th>
<th>Type/Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear Fuel Component Plant (Plant 202), Baotou, Nei Mongolia province</td>
<td>Fuel rod fabrication; operational.</td>
</tr>
<tr>
<td>Nuclear Fuel Component Plant (Plant 812), Yibin, Sichuan</td>
<td>Fuel rod fabrication; operational.</td>
</tr>
<tr>
<td>Jiuquan Atomic Energy Complex, (Plant 404), Subei, Gansu</td>
<td>Nuclear Fuel Processing Plant: Converts enriched UF₆ to UF₄ for shaping into metal; operational.</td>
</tr>
</tbody>
</table>

**Tritium, Lithium, Deuteride, and Beryllium**

<table>
<thead>
<tr>
<th>Name/Location of Facility</th>
<th>Type/Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ningxia Non-Ferrous Metal Research Institute (Plant 905), Helan Shan, Ningxia</td>
<td>China's main research and production site for beryllium.</td>
</tr>
<tr>
<td>Nuclear Fuel Component Plant (Plant 202), Baotou, Nei Mongolia</td>
<td>Tritium, Li, deuterium production; operational.</td>
</tr>
<tr>
<td>Nuclear Fuel Element Plant (Plant 812), Yibin, Sichuan</td>
<td>Probable production of tritium, Li and deuterium.</td>
</tr>
</tbody>
</table>

Source: Jones et al., Tracking Nuclear Proliferation. pp. 65–67.

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**Defining the Threats to Chinese Nuclear Facilities**

All states with nuclear facilities, civil or military, need a strong system of MPC&A because these facilities can be vulnerable to nuclear terrorism. China is no exception. Terrorists are becoming increasingly international. If they want to obtain fissile materials, they may choose to target the weakest MPC&A system. Of course, international terrorist groups would have

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difficulties operating in China because foreigners typically stand out visually, do not speak Chinese well, and would be easy to spot in the remote areas where most of China's nuclear facilities are located. But as China's borders continue to open up, international terrorism might become more of a problem.

Perhaps a greater risk than international terrorists attempting to acquire fissile materials from Chinese nuclear facilities is an increasing risk of domestic terrorism in China. In particular, Muslim separatists in Xinjiang have engaged in a number of acts of domestic terrorism. These terrorist activities reportedly reached their peak in 1997, but they have reportedly continued in recent years. (See Table 4.3 for a list of some of the terrorist activities in 1997 for which the Muslim separatists have been responsible.) The possibility that these separatists might want to sabotage a nuclear facility or to obtain fissile materials for terrorist purposes cannot be ruled out.\textsuperscript{117}

The ethnic unrest in Tibet and Inner Mongolia could also eventually erupt into domestic violence.\textsuperscript{118} While the Tibetan independence movement certainly has not erupted in the terrorism that has characterized the Xinjiang conflict, one cannot be certain that it never will. There are also nuclear facilities and military bases located in provinces near Tibet that could be targets for terrorism.

\textsuperscript{117} For a similar argument, see Evan A. Feigenbaum, "China's Strategy of Weakness," \textit{Far Eastern Economic Review}, vol. 164, no. 8 (March 1, 2001), p. 29.

\textsuperscript{118} George, "Islamic Unrest," p. 2. See also Greg Austin, "The Strategic Implications of China's Public Order Crisis," \textit{Survival}, vol. 37, no. 2 (Summer 1995), pp. 7–23.
**Table 4.3: Violent Incidents Believed To Have Been Carried Out by Xinjiang Independent Elements in 1997**

<table>
<thead>
<tr>
<th>Date</th>
<th>Place</th>
<th>Incident</th>
<th>Casualties</th>
</tr>
</thead>
<tbody>
<tr>
<td>2/5–6/97</td>
<td>Urumqi</td>
<td>Riots by 1000 people</td>
<td>More than 10 dead, including policemen, 198 wounded.</td>
</tr>
<tr>
<td>2/12/97</td>
<td>Lanzhou-Urumqi Railway</td>
<td>Train derailed by bomb blast</td>
<td>Not known</td>
</tr>
<tr>
<td>2/25/97</td>
<td>Urumqi</td>
<td>3 bus bomb blasts</td>
<td>7 dead, 60 wounded</td>
</tr>
<tr>
<td>3/1/97</td>
<td>Urumqi</td>
<td>Bomb blast reportedly at a building</td>
<td>Not known</td>
</tr>
<tr>
<td>3/3/97</td>
<td>120 km east of Yining</td>
<td>Bus bomb blast</td>
<td>Not known</td>
</tr>
<tr>
<td>3/7/97</td>
<td>East Bridge, Beijing</td>
<td>Bus bomb blast</td>
<td>2 dead, 8 wounded</td>
</tr>
<tr>
<td>4/97</td>
<td>Outside Yining</td>
<td>“Wanton” killing of Han Chinese</td>
<td>20 dead</td>
</tr>
<tr>
<td>4/24/97</td>
<td>Yining City, Xinjiang</td>
<td>Prison raid by thousands of people</td>
<td>At least 2 killed, 7 wounded</td>
</tr>
<tr>
<td>8/6/97</td>
<td>A town in Xinjiang</td>
<td>Assassination attempt</td>
<td>Wounded 3 policemen and two civilians</td>
</tr>
<tr>
<td>10/1/97</td>
<td>Kuytun City, Xinjiang</td>
<td>Bomb blast</td>
<td>22 killed</td>
</tr>
<tr>
<td>10/2–7/97</td>
<td>Shihezi City Xinjiang</td>
<td>4 bomb blasts</td>
<td>Reportedly killed many people</td>
</tr>
</tbody>
</table>


**China and International MPC&A Standards**

Because China is officially recognized as a nuclear-weapon state by the NPT, it is not bound by most of the IAEA regulations for control over fissile materials. Thus, to a large degree, China is responsible for implementing its own standards for fissile material control. However, China has voluntarily bound itself to some IAEA standards.

In 1988, China signed an agreement with the IAEA to place some of its facilities under IAEA safeguards. This agreement is published in INFCIRC/369.\(^{119}\) China currently has three facilities under IAEA safeguards: the Qinshan-1 nuclear power reactor and the HWRR-2 research reactor at the China Institute of Atomic Energy (CIAE), and the Daya Bay nuclear power reactor located near Hong Kong.\(^{120}\) China is building several additional nuclear facilities, which will also be placed under IAEA safeguards. One of these facilities is a gas-centrifuge plant, which was purchased from Russia and will be used to produce low-enriched uranium. The first stage of this facility was completed in April 1998 and has been put into operation in the

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\(^{119}\) To view INFCIRC/369, see the Center for Nonproliferation Studies web site: <http://cns.miis.edu/db/china/engdocs/iaeaj69.htm>.

\(^{120}\) Sichor, “Peaceful Fallout,” p. 24.
town of Hazhun. The second stage was commissioned in August 1998, and the third and final stage is expected to be commissioned in 2002. China is also building two CANDU (Canadian deuterium-uranium) reactors as the third stage of the Quinshan power station. These plants are being built with Canadian assistance and will also be placed under IAEA safeguards.

In addition to its voluntary agreement to place some facilities under IAEA safeguards, China has also signed several international agreements that relate to the controls over nuclear materials. The first of these was the 1979 Convention on the Physical Protection of Fissile Materials (codified in INFCIRC/274, rev.1). Although this agreement is important, it has a relatively limited scope. It applies only to transports of fissile materials used for peaceful purposes across international borders. It is silent about both defense-related fissile materials and physical protection inside a country’s borders. In addition, the treaty contains no method of verification or enforcement.

Another important international standard which China signed is the *Guidelines for the Management of Plutonium* (INFCIRC/549). These guidelines establish requirements for the management and disposition for civil plutonium and other plutonium deemed no longer required for defense. They establish MC&A standards similar to INFCIRC/153 and say that states should implement physical protection regulations “taking into account” INFCIRC/225, rev.3. These guidelines are limited, however, by the fact that they do not require the physical protection regulations established by INFCIRC/225. Nor do they say anything about the management of uranium or plutonium that is not used for peaceful purposes.

Overall, the international arrangements to which China has committed are of relatively limited use in establishing rigorous and enforceable MPC&A standards in China. Let us now examine whether China has created a domestic legal infrastructure for effective MPC&A.

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122 Sichor, “Peaceful Fallout,” p. 25.
123 To view INFCIRC/274, see the IAEA web site: <http://www.iaea.org/worldatom/Documents/infcircs/2000/infcirc274r1a7.pdf>.
126 These guidelines also state that the officially recognized NWSs should transfer to IAEA safeguards the plutonium that they no longer consider necessary for their national defense purposes. But it only requires that they take these steps as soon as it is “practicable” and places no deadline by which this transfer should occur.
China's Domestic Regulations for MPC&A


**MC&A Measures Required by Chinese Law**

From the 1960s to the late 1980s, the Chinese used a “nuclear material ledger system” in its nuclear facilities, where paper records are kept for amounts of nuclear materials.\(^{127}\) By 1990, however, China’s MC&A regulations had become much more systematic. The 1987 “Regulations” established laws requiring strict licensing procedures for nuclear facilities. Before the license is granted, the facility must “establish and maintain a nuclear materials balance system and an analysis and measurement system, and use the approved analysis and measurement method to attain specified requirements of measuring error.”\(^{128}\)

The 1990 “Rules” gave the CNNC responsibility for “establishing the accounting system of nuclear materials of the whole country.”\(^{129}\) It also clarified the MC&A requirements that nuclear facilities must satisfy. It requires a new accounting system that calculates MUF (materials unaccounted for) in the same way as that required by IAEA INFCIRC/153. The 1990 document also establishes regulations for acceptable standard error of MUF in Chinese nuclear facilities.\(^{130}\)

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\(^{128}\) 1987 “Regulations,” p. 3. Responsibility for issuing the licenses was originally given to the China National Nuclear Corporation (1990 “Rules,” p. 1). It is not entirely clear what agency will be responsible for licensing after China's recent restructuring of its nuclear bureaucracy, but it will probably be the CAEA.


\(^{130}\) MUF is calculated by the following formula:

\[
MUF = BI + A - EI - R - KL
\]

The 1990 document also establishes the following regulations for acceptable standard error of MUF:

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Relative Standard error of MUF (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uranium enrichment</td>
<td>0.2%</td>
</tr>
<tr>
<td>Uranium processing</td>
<td>0.3%</td>
</tr>
<tr>
<td>Plutonium processing</td>
<td>0.5%</td>
</tr>
<tr>
<td>Uranium reprocessing</td>
<td>0.8%</td>
</tr>
<tr>
<td>Plutonium reprocessing</td>
<td>0.1%</td>
</tr>
</tbody>
</table>
In addition to these legal requirements, China revised its nuclear materials accounting forms in 1991. These forms now conform to those used internationally. The new forms are the following:

- NMF-R01: Nuclear Material Transfer (similar to U.S. DOE form 741)
- NMF-R03: Nuclear Material Inventory Change (similar to IAEA Form ICR)
- NMF-R04: Physical Inventory (similar to IAEA Form LPI)
- NMF-R05: Nuclear Material Balance (similar to IAEA Form)
- NMF-R06: Annotation
- NMF-R07: Nuclear Material Accident

### Physical Protection Measures Required by Chinese Law

By and large, China’s legal framework incorporates the physical protection standards established by INFCIRC/225. These documents not only use the same method of categorization of fissile materials as INFCIRC/225, but they also require similar physical protection measures. See Table 4.4 for the specific physical protection measures that these documents require for each category of fissile materials.

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131 Reported in the Monterey database: <http://ens.miis.edu/db/china/MPC&A>.

132 To view the specific categories of fissile materials (Category I, II, and III materials) and the physical protection measures for each category recommended by INFCIRC/225, go to the IAEA web site: <http://www.iaea.or.at/worldatom/program/protection/inFCIRC225rev4/rev4_content.html>.
Table 4.4: Physical Protection Standards Established By Chinese Law

<table>
<thead>
<tr>
<th>For using or storing category I nuclear materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Materials must be contained in at least two complete, reliable physical barriers. Actual materials must be stored in a vault or special security container.</td>
</tr>
<tr>
<td>• Alarm or surveillance protection equipment.</td>
</tr>
<tr>
<td>• Technical protection system with alarming and monitoring installations, etc.</td>
</tr>
<tr>
<td>• 24-hour armed guards.</td>
</tr>
<tr>
<td>• Special passes or badges for all people entering the site; strict control on non-site personnel’s entrance with the procedure of registration, and full-time escort by the site personnel after access.</td>
</tr>
<tr>
<td>• A “double men and double lock” regime.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>For category II nuclear materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Two physical barriers; one barrier must be complete and reliable. Actual materials must be stored in a “strong room” type storage area.</td>
</tr>
<tr>
<td>• Alarm or surveillance protection equipment.</td>
</tr>
<tr>
<td>• 24-hour guards (preferably armed).</td>
</tr>
<tr>
<td>• Special passes for all people entering the site.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>For category III nuclear materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>• A complete and reliable physical barrier.</td>
</tr>
<tr>
<td>• Material should be placed security containers or someone should be assigned to watch material.</td>
</tr>
</tbody>
</table>

China’s legal regulations match international standards for MPC&A fairly well. If China’s nuclear facilities met these regulations, its MPC&A would probably be adequate. Unfortunately, most reliable sources indicate that China’s actual MPC&A is characterized by rigorous laws but lax enforcement. Indeed, according to Wen Hsu, a China expert at Sandia National Laboratories, while the two documents that regulate China’s nuclear controls specify the materials to be regulated, the responsibilities of the supervising authorities, the licensing process, how nuclear material accounting should be performed, and guidelines on the physical protection of nuclear materials, they do not specify how these measures were to be enforced, who would enforce them, or the criteria by which compliance would be measured. As a result, 133

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134 This equivalent to the “two-person rule,” where that no one is permitted to have access to nuclear material without another person present. To help enforce this procedure, the doors to nuclear material storage vaults require two keys and no single person is supposed to have both keys.
there is significant evidence that China’s actual MPC&A typically falls far short of its legal regulations.

**China’s Actual System of MPC&A**

It has become clear that China protects its nuclear facilities and controls its fissile materials primarily by means of the “three G’s”—guards, guns, and gates.\(^{136}\) This system mainly controls fissile materials by using guards and intimidation to keep out anyone who might attempt to steal nuclear materials. “In Russia and China, in particular, [fissile material control systems] were designed to keep ‘the outside out’ rather than ‘the inside in,’ and they relied heavily upon totalitarian instruments of social control.”\(^{137}\)

Because China is a member of the IAEA, and has some facilities under IAEA safeguards, it must certainly have a general knowledge of what is required for a modern MPC&A program. In addition, it has purchased several nuclear power facilities from France that contain modern MPC&A systems. But there is little evidence that the Chinese have designed or implemented modern MPC&A systems in their indigenous nuclear facilities.

**China’s Fissile Material Control and Accounting (MC&A)**

China did reportedly develop a computer accounting system for its nuclear fuel in 1996, which was intended to help detect the loss or theft of fissile materials.\(^{138}\) China claimed that this system met international standards for accountability. Apparently these computer systems have been installed at roughly a dozen nuclear facilities.\(^{139}\) If this information is true, this number of systems is clearly not enough to improve China’s material accountability significantly, because there are many more than 12 facilities in China that contain fissile materials. It is possible that more than 12 facilities have computerized systems for material accountancy, but China’s nuclear materials accountability will necessarily be limited by the number of computer systems it purchases for this purpose.

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139 Jones et al., *Tracking Nuclear Proliferation*, p. 55.
In addition, these computer systems are really only useful to the extent to which Chinese facilities have been set up to isolate strategic monitoring points, where one can measure the amounts of fissile materials moving through the systems. And it is not clear that the Chinese facilities are designed to allow for this. According to Annette Schaper, nuclear facilities in China (and other NWSs) "may lack designs that specifically facilitate an overview of material flows, define strategic points, provide access for taking samples, designate measurement points, contain installations that enable the application of tags and seals, and restrict human entry." No matter how good a country's accounting computers are, its MC&A will be seriously defective unless its facilities are designed so that the amounts of fissile materials contained in them can be measured easily and frequently. It is not clear that China's facilities are designed in such a way. Indeed, given its reliance on a Soviet-style system, there is no reason to believe it would have designed its facilities in this manner.

In addition, although the Chinese probably have knowledge of the specific equipment necessary for a modern, Western-style MC&A system, it is not clear that they have installed much of this equipment at their own facilities. Nor is it clear that China has undertaken the extensive designing and testing necessary to assemble MC&A equipment into an integrated system that was capable of detecting the theft of fissile materials. This was a major weakness in the Soviet system, and is probably a weakness in the Chinese system as well.

To the extent that China has no systematic MC&A, it presumably has only a limited ability to detect theft by insiders. Indeed, because Chinese nuclear facilities were probably not designed so that reliable physical inventories can be taken, China probably does not even have a precise inventory of the amount of nuclear materials in its facilities. This is the most basic step in any MC&A system, for without this knowledge there is no way to detect if any material has disappeared. Instead, China mainly trusts that its social control is such that no insider would steal any nuclear materials.


141 The three Chinese nuclear facilities that are under full IAEA safeguards would have this MC&A equipment, but those facilities that China designed indigenously probably do not have similar MC&A systems.
China's Physical Protection Systems

The most important aspect of a physical protection system is the assessment of whether a given nuclear facility can deter or defeat any potential threat. In order to do this, a state needs to carry out five steps:

1) design a basic physical protection system;
2) create scenarios for the possible kinds of attack on a given nuclear facility;
3) test to make sure that the facility’s current defenses can counter the attack;
4) fix any weaknesses discovered in the tests; and
5) repeat steps three and four until the defenses can defeat all types of attack.

While there is a small but growing literature on China’s MPC&A, there is very little specific information on the physical protection of Chinese facilities. We simply do not know whether China has engaged in such systematic designing and testing of its physical protection systems. Nor do we know whether China has created a legal structure that specifically outlines how a facility would put a physical protection system into place. Given the Soviet model for China’s physical protection, however, it is unlikely that China has taken either of these critical steps in the design and implementation of Western-style physical protection systems. If China has not taken these steps, there is no way to be sure that the physical protection systems at their nuclear facilities would be able to repel a dedicated attack.

As noted above, China’s physical protection has mainly relied on the presence of guards at its nuclear facilities to deter and defend against attacks. The guards at smaller nuclear facilities are provided by the facility itself, while the guards at major facilities are members of China’s armed forces. It is simply not known whether China has taken all appropriate steps to ensure that these guards are properly armed or trained.

Until recently, there were few concerns about the weakness of physical protection systems at Chinese nuclear facilities. Like the Soviet Union before its collapse, China’s central authorities maintained massive social controls that pervaded every aspect of the society. Just as no one was worried about people stealing fissile materials in the Soviet Union, there was relatively little reason to fear that people would attempt to steal these materials in China. But this has changed in recent years. Since China began to make economic reforms in the 1970s, there has been a significant erosion of societal controls and central government authority. Crime

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rates in China have soared in recent years, and people in China, including local government officials, routinely evade government dictates.\textsuperscript{143}

Moreover, recent governmental restructuring and budget cutbacks have cost many governmental officials their jobs, including many in the nuclear sector and the military.\textsuperscript{144} It is difficult to determine how these cutbacks will affect the nuclear sector, but the result could be a larger pool of disgruntled people who might be tempted to steal nuclear materials and sell them, who might be vulnerable to recruitment by terrorist or organized crime groups, or who might provide information on security measures to support an attack.\textsuperscript{145} These problems are probably much less severe than the problems in the Russian nuclear complex (e.g., people are probably still getting paid regularly), but they do exist in an incipient form. Chinese nuclear materials still probably remain under tight central government control, but these problems are clearly widespread in other sectors of the Chinese economy and government and could eventually spread to the nuclear sector.

Because China’s major nuclear weapons facilities are located in isolated areas, however, they will tend to be less affected by the weakening of societal controls.\textsuperscript{146} It would therefore be easier for the government to maintain strict oversight of these facilities and much more difficult for outsiders to attack the facilities. Nevertheless, the general loosening of societal controls is troubling because China has relied on these controls to discourage any attacks on its nuclear facilities.

Conclusions About China’s MPC&A

China’s current system of MPC&A apparently has worked well so far, but there is no guarantee that it will do so in the future. As we have seen, there are terrorist groups that might attack China’s nuclear facilities. In addition to international terrorists who might be interested in obtaining nuclear materials, there are angry and disenfranchised groups within China that could be interested in engaging in a broader range of terrorist activities against the central authorities.


\textsuperscript{144} Hsu, “The Impact of Chinese Government Restructuring,” p. 159.

\textsuperscript{145} The author would like to thank an anonymous reviewer for this suggestion. See also Jones and et al., \textit{Tracking Nuclear Proliferation}, p. 54

\textsuperscript{146} This was certainly the case during the Cultural Revolution, though the political crisis did eventually affect the nuclear sector as well. See Lewis and Xue, \textit{China Builds the Bomb}, pp. 203–204.
Given the current evidence of the protective measures at China’s nuclear facilities, it is possible that a well-organized terrorist attack could be successful.

But the most significant weaknesses in China’s system of MPC&A could become critical in times of political and economic crisis. Clearly, the experience in Russia shows the limitations of an authoritarian type of control during such crises. China has had its share of crises in the past and might have additional ones in the future.147 If such crises were to occur, China’s controls over its fissile material stockpiles could become significantly weaker.148

Several different kinds of crises could undermine China’s controls over its fissile material stockpiles. If China underwent a severe economic downturn, it could face the same kinds of problems that Russia is now facing. If the wages of the scientists and guards at Chinese nuclear facilities were reduced, they might be tempted to supplement their incomes by selling fissile materials on the black market.149 Given China’s lack of a systematic MC&A system, it probably would not be able to detect this kind of insider theft.

A second way that China’s MPC&A could collapse is if there were a decentralization of power in China. As we have seen, a number of scholars have argued that regionalism is increasing in China, and that the Chinese Communist Party is losing its influence.150 China has relied heavily on strict social controls to deter any insider theft or terrorist attempts. As these societal controls weaken, we could see a dramatic increase in these illicit activities. A similar pattern in Russia and the Newly Independent States appeared following the collapse of the Soviet Union.

Finally, a sustained leadership conflict or political crisis could undermine China’s MPC&A. As we have seen, the Cultural Revolution disrupted nuclear production and caused violent clashes in Chinese military research facilities. While it is unlikely that another political crisis on the scale of the Cultural Revolution will occur again in China, a leadership conflict could distract attention and interfere with close supervision of the Chinese nuclear complex.

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147 See pp. 164 ff. above for a discussion of the major political crises that occurred while China possessed nuclear weapons.
148 Jones et al., Tracking Nuclear Proliferation, p. 54.
149 The loosening of the strict societal controls of the CCP have also allowed more opportunities for thefts and organized crime. In recent years, there have been numerous reports of skyrocketing crime rates in China. See Elizabeth Rosenthal, “China’s Fierce War on Smuggling Uproots a Vast Hidden Economy,” New York Times, March 6, 2000.
150 See, for example, Gerald Segal, “China Changes Shape: Regionalism and Foreign Policy,” Adelphi Paper, no. 287 (London: IISS, 1994), pp. 3–72; Hua, “China’s Security Dilemma,” p. 3; Jones et al., Tracking Nuclear Proliferation, p. 54; and Austin, “China’s Public Order Crisis,” pp. 7–23.
Why Hasn’t China Done More, Since It Knows Some of the Basic Requirements for a Modern MPC&A System?

There are several reasons why China’s actual MPC&A often falls short of its own legal requirements. The first obvious reason is that China is a resource-limited country. Stringent physical protection regulations are very expensive to implement. Although Chinese expenses would presumably be lower than in the United States, in many cases, Chinese scientific facilities have been underfunded and probably cannot afford to meet the physical protection regulations established by Chinese law.

In addition, Chinese officials often have difficulty justifying the high cost of modern MPC&A systems typically used by the Western countries. Because China is a poor country, it could either use its resources to feed its citizens or strengthen its economy or military, or it could use them to improve its MPC&A. China’s limited financial resources have often caused it to place safety and security as lower priorities than other objectives.

Another reason why the Chinese have not improved their MPC&A is that there is a lack of coordinated policy among the different bureaucracies that have responsibility over China’s nuclear complex. One could characterize the Chinese nuclear complex as “stove-piped,” where there is not much communication among the different bureaucracies or coordination of their nuclear policies. According to Wen Hsu, “the government departments [in China’s nuclear establishment] have continued to act as fiefdoms that jealously guard their prerogatives, to the extent that their possessiveness has discouraged interdepartmental exchanges.” Moreover, each of the bureaucracies has limited resources, and each might be unwilling to pay for MPC&A technologies that it believes another agency should pay for.

But the main reason that China has not improved its MPC&A more than it has is that the Chinese simply have not seen the need for the stringent MPC&A implemented by Western countries. The Chinese have stated publicly “that their method of MPC&A is ‘similar to that of the Russians,’ which was mostly dependent in the past on security personnel.” Although it has become clear that such an MPC&A system is particularly weak during political and economic

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151 For example, in the United States, a perimeter intrusion detection and assessment system (PIDAS) for the physical protection of facilities containing Category I materials costs nearly $1,000 per foot. A PIDAS would include the following: (a) fences and intrusion sensors, (b) alarm assessment video cameras and lights, (c) central and secondary alarm stations, (d) an access control portal with nuclear material detection sensors.

152 Hsu, “The Impact of Chinese Governmental Restructuring,” p. 165; see also pp. 152, 154

crises, the Chinese consider these methods of MPC&A to be adequate for now because their current political, social, and military situation is relatively stable.\textsuperscript{154}

**The U.S./China Lab-to-Lab Collaborative Program (CLL), 1995–1998**

In part in an effort to better understand and to address some of these proliferation concerns, a formal letter exchange was begun in 1995 among the directors of nuclear laboratories in the United States and China, following informal contacts under careful government oversight the previous year. It was determined that Department of Energy nuclear laboratories and their counterpart research facilities in China have many mutual scientific interests, and that laboratory-level collaboration was desirable in specific areas.\textsuperscript{155} These discussions resulted in the "U.S.-China Lab-to-Lab Technical Exchange Program" (CLL).\textsuperscript{156} Since their inception, the CLL programs have covered topics ranging from nuclear materials management (MPC&A), to verification technologies critical to the Comprehensive Test Ban Treaty (CTBT), to additional efforts in export controls. This paper will focus specifically on MPC&A collaborations.

**CLL Meetings and Workshops on MPC&A, 1995–1998**

The first meeting where U.S. and Chinese scientists discussed MPC&A technologies occurred in 1995. In this meeting, American scientists from Lawrence Livermore, Sandia, and Los Alamos National Laboratories met with Chinese scientists from the China Academy of Engineering Physics (CAEP) and the Institute of Applied Physics and Computational Mathematics (IAPCM). This second round of discussions began in January 1996, when American scientists from Livermore, Sandia, and Los Alamos met with Chinese scientists at the IAPCM for a workshop on MPC&A technologies. During the workshop, scientists from both countries presented papers discussing the current MPC&A practices, technologies and methodologies used in each country.

In 1997, Sandia National Laboratories held a two-week-long course in China on physical protection system design for nuclear facilities. It was held at the China Institute of Atomic

\textsuperscript{154} Ibid., p. 322
Energy in Beijing from March 29–April 10. These workshops helped train Chinese scientists in Western methods for designing and installing integrated physical protection systems.

In 1998, Sandia National Laboratory held a workshop in China on MC&A techniques. This workshop helped the Chinese develop strategies for identifying strategic monitoring points, installing measurement gauges, etc. If implemented in Chinese nuclear facilities, these MC&A procedures and technologies would help the Chinese take precise physical inventories of the fissile materials in their nuclear facilities and subsequently detect any theft of these materials.


The principle Los Alamos activity, and a flagship CLL project, was to build a model MPC&A system in China to demonstrate Western-style MPC&A techniques and technologies. Work on this project began in 1996 and was completed in 1998. The opening of the demonstration took place in July 1998. The purpose of this MPC&A demonstration was to “provide an important foundation for building future activities for nuclear materials management in China.”157 It was hoped that the model facility would help China and the U.S. achieve this end “through development of common approaches and deployment of integrated systems of modern technologies.”158

A great deal of modern MPC&A technology was installed at this facility. The new equipment included access-control devices such as motion detectors, cipher-activated locks, magnetic card readers, and hand-geometry readers. Screening and monitoring devices were installed, such as metal detectors, portal radiation detectors, and an NTvision camera remote-monitoring system. Equipment for materials measurement and tracking systems was also installed, including gamma spectrometers for nuclear materials assay, a complete bar-code inventory system, and tamper-resistant seals.159 The United States provided most of the equipment except the facility itself, the security fence, and the nondestructive assay equipment, which were provided by China.

These China Lab-to-Lab collaborations were designed to help create a “safeguards culture” in China by showing them the advantages of modern MPC&A systems. The CLL program made some progress in this area, but it is clear that more still needs to be done.

159 Ibid., pp. 7–22.
The Reasons for the Recent Progress and the Prospects for the Future

Although the Chinese have not demonstrated that they are particularly concerned about their current MPC&A, there had been some progress in the CLL collaborations. There are several reasons for the Chinese willingness to improve their MPC&A. The first reason is national pride. In the eyes of the international community, modern safeguards are a good sign of a responsible, industrialized country. Chinese leaders have been willing to work to improve China's MPC&A because they do not want China to be as considered Third World country.

But perhaps the most important reason for China's willingness to make some improvements in its MPC&A is because China has a strong interest in improving relations with the United States. It is not clear that China would have made any of the improvements that it did without the influence of the United States being brought to bear on the matter.

In 1998, policymakers and arms control experts hoped that the CLL program would help build a strong foundation of trust and mutual cooperation between the United States and China on issues of nonproliferation and arms control. CLL collaborations were to encourage increased transparency and mutual understanding of the nuclear programs in both countries while protecting national security interests in each country, and help build a strong basis for future MPC&A programs in China. In the aftermath of the 1999 Cox Report and the allegations of Chinese espionage, however, there was been a complete cessation of contacts under the CLL program. The Chinese canceled visits previously planned, and no new events have been scheduled. As a result, the continued existence and nature of the CLL program are very uncertain at this time.

The recent worsening of relations between the United States and China has threatened to halt any further progress in the improvements of China's MPC&A. Because it appears that the U.S. influence was necessary for China to make any improvements to its MPC&A, now that the U.S. influence has been removed, it is unlikely that China will make any more improvements on its own. Indeed, plans under the CLL program for actual implementation of some MPC&A measures at Chinese nuclear facilities were curtailed as a part of the reduction in U.S.-Chinese contacts.

161 To view the allegations of Chinese espionage in "U.S. National Security and Military/Commercial Concerns with the People's Republic of China," otherwise known as the Cox report, see <http://www.access.gpo.gov/congress/house/hr105831/V1-06-Chap2.pdf>.
Part III: Conclusions

Available information indicates that China has not sufficiently implemented the proper controls over its nuclear arsenal and fissile material stockpile. In particular, both China’s command and control and MPC&A appear to be vulnerable during extreme economic and political crises. The following conclusions can be drawn about China’s nuclear controls.

- **The risk of an accidental launch of China’s nuclear weapons could increase in the near future.**

  Since China currently stores most of its missiles unfueled and without their warheads mated, there is currently very little risk of an accidental launch of China’s nuclear weapons during normal, peacetime circumstances. However, the risk of accidental launch could increase significantly during a nuclear crisis if China were to fuel the missiles and mate the warheads to bring its arsenal to a state of launch-readiness. But there is an increasing cause of concern, because China appears to be changing its current method of storing and deploying its nuclear weapons. China is moving to a mobile, solid-fueled missile system, in which its missiles will be stored fully-fueled. And because of the necessity for increased missile mobility, it is also quite possible that China will begin storing its missiles with their warheads mated. If China’s new missile system is stored in this state of launch-readiness, the risk of an accidental launch of a Chinese nuclear weapon could significantly increase.

- **The risk of the unauthorized use of China’s nuclear weapons could be very high during political and economic crises.**

  During extreme political or economic crises, the chain of command over China’s nuclear weapons could seriously erode. The PLA has demonstrated relatively weak discipline during past crises and it could turn against the central government if China underwent another such crisis. In addition, there is evidence of increasing regionalism and general dissatisfaction with the central government. There is also a possibility that China’s command and control could collapse if some of China’s provinces revolted against the government. These risks are particularly troubling because China’s nuclear weapons do not appear to contain use-control devices, such as PALs or launch codes that need to be entered before the nuclear weapon can be launched.
• *China's MC&A is probably incapable of detecting an insider theft of nuclear materials.* Although many Chinese nuclear facilities have some MC&A equipment, they have not integrated this equipment into an effective system. An intelligent insider would therefore probably be able to defeat the system and smuggle nuclear materials out of a nuclear facility. While China's authoritarian regime would still probably discourage anyone from deciding to steal nuclear materials, China's strict societal controls are loosening. During an economic or political crisis, an insider could therefore be tempted to steal China's nuclear materials for sale on the black market or for other purposes.

• *It is not clear that the physical protection of Chinese nuclear facilities could repel a dedicated attack.* While the physical protection of Chinese nuclear facilities is probably superior to their MC&A, it is not clear that it would be able to defend against an outsider attack. China has not identified potential threats to its nuclear facilities or performed an assessment of whether it could defeat these threats. Without this, there is no way for China to be certain its physical protection system can withstand credible threats. It is also not clear that the guards for Chinese nuclear facilities are properly trained or armed. For the physical protection its nuclear facilities, China mainly relies on its societal controls and on the isolation of the facilities. But it is not clear that these will be adequate for physical protection in the future, especially during political crises. Chinese facilities are therefore potentially vulnerable to a dedicated attack, whether it is conducted by terrorists, rogue elements within the Chinese military, or even another country.

• *China probably would not improve its MPC&A without U.S. encouragement.* Although it is clear that the MPC&A for Chinese nuclear facilities falls short of both international standards (such as those recommended by the IAEA) and China's own legal standards, most evidence indicates that China does not see much urgency in improving its MPC&A. Most Chinese officials who talked to U.S. scientists have said their nuclear materials are secure because no one steals in China. But this appears to be changing as China's societal controls loosen. While the United States is concerned that China's controls will eventually no longer be adequate, Chinese officials have generally not demonstrated the same level of concern. The United States must continue working with the Chinese to help create a safeguards culture in China, where everyone from high-level
politicians to the lowest-level guard recognizes the importance of rigorous MPC&A procedures and technologies.

These conclusions give us reason to be pessimistic about the risks associated with the proliferation of nuclear weapons. As we have seen, this case study has identified a number of potential weaknesses in China’s controls over its nuclear weapons arsenal and fissile material stockpile and potential risks of accidental, unauthorized and inadvertent use.

The Chinese case is particularly troubling because China has had plenty of time to improve its controls, but for various reasons has been unable or unwilling to do so. Because emerging NWSs will probably encounter many of the same constraints that China has, we should have serious doubts whether they will be likely to develop rigorous nuclear controls. In the following chapter, we will examine the nuclear controls and nuclear risks in two emerging NWSs, India and Pakistan, to determine how serious these concerns should be.
Chapter 5: India and Pakistan

Why Study South Asia?

India and Pakistan are critical cases for the optimist-pessimist debate. They are important for two essential reasons. First, because India and Pakistan have a history of conflict, they are a useful case for determining whether or not the spread of nuclear weapons increases or decreases stability. Indeed, optimists have generally argued that nuclear weapons have increased stability in the region. Pessimists, on the other hand have argued that nuclear weapons have increased tensions and the risks of nuclear war. As we will see, however, a close examination of the history of the tensions in the region and the directions that the nuclear programs in India and Pakistan are taking reveals much greater support for the pessimists’ arguments.

The second reason why India and Pakistan are essential cases for the proliferation debate is that they help illustrate the nuclear systems and the types of controls that emerging NWSs are likely to adopt. Seng and Karl, in particular, point to these countries as examples of why emerging NWSs will probably have safer arsenals than the superpowers because they will remain satisfied with small, non-weaponized nuclear forces. To a certain degree, some of these optimistic predictions have been disproved by the dual tests conducted by India and Pakistan in 1998. Neither country remained content merely with an “existential” deterrent, though they now are somewhere in a no-man’s land between existential and minimal deterrence. Although it is not yet clear what types of weapons systems and deployment options the two countries will

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choose to adopt, this chapter identifies a number of troubling trends in the two countries toward weaponization and deployment.

Unlike previous chapters, which focused on a single NWS, this chapter will focus on both India and Pakistan. This is partly because the issues affecting each country are so intertwined that it is easier to deal with them together. But it is also partly due to the fact that there is much less available information on Indian and Pakistani nuclear controls.

It is also the case that a great deal is still undetermined in India’s and Pakistan’s nuclear programs. For example, it remains to be seen whether these countries will actually weaponize their nuclear devices and deploy them in the field. As we will see, however, most indications are that they probably will develop these capabilities. If they continue in the direction they are currently headed, the primary question is when, not if, they will develop these capabilities. In this chapter, we will also examine whether available information indicates that India and Pakistan have adequate command and control and MPC&A systems in place. Although there are admittedly significant gaps in information, and the character of the nuclear programs in South Asia is still somewhat undetermined, this chapter will argue that most indications appear to be that the South Asian case generally supports the pessimist position.

Part I: Indian and Pakistani C³I and the Risks of Accidental, Unauthorized, and Inadvertent Use

History of the South Asian Nuclear Rivalry: “The Most Dangerous Place on Earth”

South Asia is a particularly unstable region for a number of reasons. Regional tensions remain high due to ongoing political dynamics between India and Pakistan, the ongoing conflict over Kashmir, the 1998 nuclear tests and subsequent missile tests, and the October 1999 military coup in Pakistan. In addition, India cites the threat from Chinese strategic forces and China’s nuclear modernization effort as additional justifications for its nuclear program. The relations between India and China increase the tensions between India and Pakistan because Pakistan views any improvement in New Delhi’s deterrent capability vis-à-vis China as an additional threat to itself. India also views China’s continued assistance to Pakistan’s nuclear and missile

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4 Ibid., p. 22.
programs as an effort to undermine India’s security. When these sources of regional tension are coupled with the history of violence and extreme mistrust between India and Pakistan, the resulting environment is extremely volatile. In the following sections, I will examine the history of conflict between India and Pakistan, and why it led President Bill Clinton to describe South Asia as “the most dangerous place on Earth.”

India and Pakistan have fought three interstate wars since 1947. This number rises to four if one considers the 1999 Kargil conflict a war. Because the number of people killed in the 1999 conflict was more than 1,000 on each side, it exceeds the level typically categorized as a war.\(^5\) Since their independence, relations between the two countries have been constantly fraught with mistrust and conflict. Soldiers on both sides continually shoot at each other across the Line of Control (LOC) in Kashmir, and several incidents—including Brasstacks (1986–1987), the Kashmir crisis (1990), and the Kargil War (1999)—ran serious risks of nuclear escalation.

**Brasstacks (1986–1987)**

In November–December 1986, India began field simulations for a large-scale military exercise, code-named “Brasstacks.” The field simulations took place in the desert of Rajasthan, roughly 100 miles from the Pakistani border. This location is reportedly an ideal staging point for an invasion of the Pakistani state of Sind, which would effectively cut Pakistan in half.\(^6\)

Based on its own intelligence, Pakistan feared that India was planning to convert the exercise into an attack.\(^7\) These fears were heightened because India provided incorrect information about how long the exercises would last.\(^8\) Pakistan was ending its own annual exercises at the time. Instead of immediately removing his forces to their peacetime locations, the commanding general, Khalis Muhamud Arif, deployed his armored units north of the Sutlej River to ensure that his troops would be optimally positioned defensively if Indian troops attacked. Although Arif deliberately positioned his troops in such a way as to allow Indian

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\(^5\) Typically, an interstate conflict is classified as a war if there were over 1,000 battle deaths. See the J. David Singer and Melvin Small, the Correlates of War Project, University of Michigan, [http://www.umich.edu/~cowproj/](http://www.umich.edu/~cowproj/). For the numbers of Indian and Pakistani troops killed in the Kargil War, see Sen, “India and the Bomb,” p. 36; Raj Chengappa, “Kargil: Holding the Heights,” *India Today*, August 16, 1999, p. 46; Rahul Bedi, “The Real Cost of Victory,” *AsiaWeek*, August 13, 1999.


reconnaissance to recognize their defensive posture, to his surprise, his troop movements went unnoticed for two weeks. When the Pakistani troops were finally located by Indian intelligence, their defensive positioning went unnoticed and near-panic ensued in New Delhi as Indian officials feared that Arif was preparing for an attack.9

This incident dramatically increased tensions in the region and led to mobilization of troops on both sides, border skirmishes, and exchanges of fire between Indian and Pakistani troops.10 Because both India and Pakistan reportedly had a crude nuclear weapons capability at this time, if the incident had escalated into a larger-scale military conflict, the conflict could have had a nuclear dimension. According to Mario Carranza, "by providing Pakistan with the wrong information about the duration of a gigantic military exercise on its border, and deploying its military forces in a provocative manner, India precipitated a crisis that could have led to a nuclear confrontation."11

The crisis reached its height on January 24, 1987, when both sides made several saber-rattling declarations and Indian troops advanced to the border because Pakistan had not withdrawn its troops from front-line positions. On January 28th, Indian and Pakistani troops exchanged fire in Kashmir, while leaders in both countries announced diplomatic negotiations to solve the crisis. The two countries began high-level negotiations on January 31, and began a sector-by-sector pullout of troops deployed along the international border on February 4.12

Although some optimists have argued that this incident actually demonstrates that nuclear deterrence restrained both sides because the incident did not escalate into a full-scale border war,13 both sides took very serious risks during the incident. According to Mario Carranza, a minor incident in this highly-charged environment could have triggered a major military conflict, which could easily have escalated into a nuclear conflict.14

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9 Joeck, "Maintaining Nuclear Stability in South Asia," pp. 24–25. For an additional explanation of this crisis, see Bajpai et al., Brasstacks and Beyond.
11 Ibid., p. 116.
12 Ibid., p. 117.
Kashmir (1990)

In 1989, terrorists sparked a conflict that again almost brought India and Pakistan to brink of war. The origins of the conflict can be traced to Indian Prime Minister Rajiv Gandhi’s attempts to manipulate the outcome of state elections in 1987. Gandhi’s efforts sparked a wave of terrorism, which resulted in the kidnapping of the Indian Home Minister’s daughter in late 1989. Although she was released unharmed, India accused Pakistan of supporting the Kashmiri Muslim insurgency. Both sides again engaged in a series of threats, most likely including nuclear threats. Again, large numbers of troops were deployed on each side of the border. During the crisis, the United States reportedly intercepted a message to the Pakistan Atomic Energy Commission ordering it to assemble at least one nuclear weapon. As tensions mounted, Pakistani Foreign Minister Sahabzada Yaqub Khan flew to New Delhi, where he held a strained meeting with his counterpart, Inder Gujral. The United States was sufficiently concerned that it sent a high-level delegation under Deputy National Security Advisor Robert Gates to mediate.

Optimists have again argued that nuclear deterrence restrained the countries from going to war. Recent assessments, however, indicate that India did not take seriously the possibility of a nuclear threat from Pakistan. Instead, Indian leaders were primarily concerned about avoiding a conventional war with Pakistan, but “neither India nor Pakistan seemed able or willing to defuse the situation. They had talked themselves into corners from which domestic and interstate politics would not allow them to escape.” As with many of the incidents between India and Pakistan, this crisis demonstrates how mutual mistrust, domestic factors, and non-state actors create situations that run a high risk of spiraling out of control. According to Neil Joeck, the 1990 crisis contradicts “the confident argument that central decision-makers are able to control behaviour on the ground in Kashmir and therefore prevent war.”

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17 Ibid., p. 117–118.
21 Perkovich, India’s Nuclear Bomb, p. 311.
22 Ibid., p. 308.
Kargil (1999)

Confident that its nuclear forces would deter a large-scale retaliation, Pakistan sent troops across the LOC into the Indian-controlled Kargil Heights in May 1999. They surprised and defeated an Indian sentry division, then proceeded to push further into Kargil. From their positions, Pakistani troops threatened not only Highway 1A, the lifeline between Kashmir and Ladakh, but also India’s hold on Sainjan.24 India responded by sending troops into the region. Several weeks of intense fighting ensued, which included heavy artillery and air attacks. By mid-1999, the Vajpayee administration threatened to extend fighting beyond the LOC if Pakistan did not withdraw its troops from Indian-controlled Kashmir.25 Although India claims that it did not cross the LOC during the fighting, it would have been nearly impossible to prevent its aircraft from crossing the LOC, given the heavy air attacks India supported. Indeed, two of India’s MiG aircraft were reportedly shot down on the Pakistani side of the LOC.26 India also signaled its intent to escalate the conflict by massing its troops along the LOC and the international border.27 U.S. satellites also reportedly detected elements of the Indian Army’s main offensive “strike force” loading tanks, artillery and other heavy equipment onto flatbed rail cars.28

When an outbreak of a larger conflict appeared imminent, Pakistani Prime Minister Nawaz Sharif asked U.S. President Clinton to mediate between the two sides. During a meeting on July 4 with Clinton, Sharif promised to withdraw Pakistani troops. On July 11, the Indian and Pakistani Directors-General of Military Operations met and reached an agreement on Pakistan’s withdrawal. Pakistani troops began to withdraw by mid-July.29

During the conflict, Pakistan threatened to use the “ultimate weapon” and warned of “irreparable losses” if India crossed the LOC,30 and according to some reports, India put its
nuclear forces on alert. U.S. intelligence agencies estimated at the time that the chances of a nuclear exchange were in the "50-50" range. Most alarmingly, retired Admiral L. Ramdas, former Chief of Staff of the Indian Navy, has reported that over a dozen people in responsible positions on both sides advocated the use of nuclear weapons during the conflict. It is hard to predict what would have happened if the United States had not intervened, or if Indian forces had not gained a military advantage before the U.S. intervention, but it is quite likely that the conflict would have escalated further, greatly increasing the risks of a nuclear exchange. According to Samuel Berger, the national security advisor to President Clinton, the United States "helped pull nuclear-armed India and Pakistan from the brink of what might have been a catastrophic war."

Unstable Deterrence: Misapplied lessons from the Cold War

Although India and Pakistan have adopted the language of deterrence that was used during the Cold War, it is not clear that they understand it in the same way that the United States and the Soviet Union did. During the Cold War, the United States and the Soviet Union engaged in proxy wars in other countries, but never against each other. The risks of an escalation into direct conventional war against each other were thus relatively small, except during acute incidents such as the Cuban missile crisis and the 1973 Middle East crisis. India and Pakistan, however, have engaged in both extended proxy wars and direct interstate wars on each other's territory, and the risks of escalation into a full-scale conventional war have been very great.

India has adopted a policy of “no first use,” but maintains a military doctrine that includes waging limited conventional wars with nuclear-armed foes. Pakistan, on the other hand, has maintained that it will use nuclear weapons in response to either conventional or nuclear attacks from India. While the United States also maintained a first-use policy in response to an attack from the Soviet Union against the United States or West Europe, there are significant differences in the way India and Pakistan approach deterrence. Since 1989 Pakistan has intensified support for its proxy war in Kashmir in the belief that its nuclear weapons effectively countered India’s conventional superiority. Once Pakistan demonstrated its nuclear capability in 1998, Pakistani security managers were even more convinced that they could deter India’s conventional forces. Indeed, according to most accounts, in the 1999 Kargil War, the Pakistani military intervened across the LOC into Indian-administered Kashmir precisely because it was confident its nuclear weapons would deter India. Even during the conflict itself, a senior Pakistani official stated that “The Indians cannot afford to extend the war to other areas in Kashmir, leave aside launching an attack across international boundaries” because of the “risk of nuclear conflagration.” But Indian officials had the opposite opinion. They, in turn, were confident that their conventional superiority was sufficient to counter Pakistan’s nuclear capability. These divergent opinions brought the two countries to the brink of a full-scale war.

The Kargil War clearly demonstrates how the Indian and Pakistani understandings of the role of their nuclear weapons have increased the likelihood of armed conflict and the risks of nuclear war. And yet, even then, both sides appear to have drawn the wrong lessons from the conflict. On the Pakistani side, the military regime claims that the Kargil conflict demonstrates the effectiveness of nuclear deterrence because it prevented an Indian conventional military attack. On the Indian side, political leaders claim that Pakistan’s nuclear capability only deters the use of nuclear weapons, and threaten to resort to a limited conventional war should unrest in

37 In May 2001, India conducted a large-scale military exercise explicitly intended to demonstrate India’s ability to fight battles in the backdrop of nuclear weapons.
Kashmir continue at present levels. India has therefore increased efforts to improve its conventional and nuclear capabilities vis-à-vis Pakistan.

India's and Pakistan's Current Nuclear Capabilities and Delivery Systems

**Indian and Pakistani Nuclear Capabilities**

After nearly 25 years of “opaque” nuclear programs, both India and Pakistan decisively demonstrated their nuclear capabilities in a series of reciprocal tests in 1998. On May 11 and 13, India shocked world by testing five nuclear devices and subsequently declaring itself a nuclear-weapons power. (See Table 5.1 for a summary of India’s nuclear tests.) Although India had previously demonstrated its nuclear capability in May 1974 by detonating a nuclear device in what it called a “peaceful nuclear experiment,” this new series of tests marked a turning point in India’s nuclear program and constituted an official declaration to become a NWS. Following the tests, an Indian spokesman stated that India now had “a proven capability for a weaponized nuclear program.”

India claims that this capability includes the potential for sub-kiloton and thermonuclear devices, though international experts have contested this claim.

India’s 1998 tests triggered a Pakistani response two weeks later, when Pakistan detonated six nuclear devices. (See Table 5.1 for a summary of Pakistan’s nuclear tests.) In the months that followed the tests, relations between the two countries worsened significantly and both countries conducted a series of missile tests.

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45 Quoted in Proliferation: Threat and Response, p. 23.

46 Independent analysis of the seismic data gathered from the tests has indicated that the official yields of the tests fell far short of the official announcements. In particular, the seismic data collected during the May 11 test appears to rule out a successful detonation of a thermonuclear device. See Brian Barker and Terry Wallace, “Monitoring Nuclear Tests,” Science, September 25, 1998.
Table 5.1: Nuclear Tests by India and Pakistan

<table>
<thead>
<tr>
<th>Location</th>
<th>Date</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pokhran, Rajasthan</td>
<td>May 18, 1974</td>
<td>15 kT</td>
</tr>
<tr>
<td>Pokhran, Rajasthan</td>
<td>May 11, 1998</td>
<td>43 kT thermonuclear, though disputed. 12 kT fission Subkiloton</td>
</tr>
<tr>
<td>Pokhran, Rajasthan</td>
<td>May 13, 1998</td>
<td>0.2 kT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.6 kT</td>
</tr>
</tbody>
</table>

Pakistan's Nuclear Tests

<table>
<thead>
<tr>
<th>Location</th>
<th>Date</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chagai Hills</td>
<td>May 28, 1998</td>
<td>Pakistan claims that its five tests were of a combined explosive force of 40–45 kT of which one was in the 30–35 kT range.</td>
</tr>
<tr>
<td>Chagai Hills</td>
<td>May 30, 1998</td>
<td>Claimed yield was of 15–18 kT.</td>
</tr>
</tbody>
</table>

Delivery Systems for Nuclear Weapons

India and Pakistan both have bombers that could deliver nuclear weapons, though India has a significant superiority. Pakistan reportedly has about 50 front-line nuclear-capable bombers, while India has roughly 230–300.4 A large proportion of these aircraft are based close to the border between the two countries (near Lahore and New Delhi).49

Both countries have also engaged in extensive missile programs. In effect, a slow-speed nuclear and missile arms race is currently underway between the two countries.50 In the following sections, I will examine the burgeoning missile capabilities in each country.

Indian Ballistic Missiles

Prithvi SS-150 SRBM, SS-250 SRBM, SS-350 SRBM

There are three versions of this short-range missile, each of which is mobile and nuclear-capable.51 The Prithvi is liquid-fueled and uses basic propulsion technology from the Russian SA-2 surface-to-air missile. The Prithvi I has a range of 150 km and payload of 1,000 kilograms.

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50 Proliferation: Threat and Response, p. 22.
51 Pravin Sawhney, “Pakistan Scores Over India in Ballistic Missile Race,” Jane’s Intelligence Review, November 2000, p. 33.
and has been produced for use by the Indian Army.\(^5\) In 1994, the army ordered 75 Prithvi I missiles and 20–50 are believed to have been delivered to the 333d Missile Group.\(^5\) The Prithvi II has a 500 kg payload and a range of 250 km and was designed for use by the Air Force.\(^5\) The Prithvi III, also called the Dhanush, is similar to the Air Force version and is intended to be launched from a surface vessel. The Dhanush was unsuccessfully flight-tested in April 2000.\(^5\)

The Prithvi is essentially a Pakistan-specific weapon, and can target half of Pakistan. One major drawback of the Prithvi is that it uses a highly-volatile liquid fuel, which has to be loaded immediately prior to launch.\(^6\) The Prithvi’s fuel significantly reduces its usefulness as a mobile missile, and has caused some analysts to doubt that the Prithvi would be used to carry nuclear warheads.\(^7\) According to some reports, however, more stable solid-fuel versions of the Prithvi may also be under development.\(^8\)

**Agni I**

This medium-range, nuclear-capable missile has an estimated range of 2,000 km with a 1000 kg warhead.\(^9\) Because of the Agni’s longer range, it would be able to target all of Pakistan, as well as many key targets in China.\(^6\) The Agni I is a two-stage missile, using both solid and liquid fuel. The first stage reportedly uses the same first stage solid-fueled booster as that used on India’s Satellite Launch Vehicle-3 (SLV-3),\(^6\) while the second stage is believed to be a modified liquid-fueled Prithvi-I.\(^6\) If this is true, then the liquid fuel used in the Agni I is probably the same volatile fuel used in the Prithvi, which means that it must also be fueled immediately before use.

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51 *Proliferation: Threat and Response*, p. 25.
52 Carnegie Non-Proliferation Project; quoted in Joeck, “Nuclear Relations in South Asia,” p. 139.
53 *Proliferation: Threat and Response*, p. 25.
54 Ibid., p. 25.
55 Ibid., p. 25.
59 *Proliferation: Threat and Response*, p. 25.
60 Ibid., p. 25.
61 See the discussion of the SLV below.
62 FBIS article: fbis10271998001722.
Agni II

The Agni II is a two-stage, rail-mobile, solid-propulsion missile with a range of approximately 2,000–2,500 km. It was successfully tested on April 11, 1999 and January 17, 2001. Because this missile uses solid fuel, it avoids some of the difficulties with fueling that have been encountered by the Agni I. Since it does not use a volatile and corrosive liquid fuel, it is possible to prepare the missile for launch much more safely and rapidly. Its solid fuel would also allow India to fire the missile from a mobile platform and possibly allow India to adopt a rapid-response capability (where the warheads are stored assembled and mated to ballistic missiles). Thus, this missile would increase the safety and survivability of India's nuclear forces, but it could also increase instability and risks of accidental, unauthorized, and inadvertent launches. After the 2001 test, a senior Indian government official again stated that India plans to introduce the Agni II into its arsenal later in the year.

Agni III

India is also reportedly attempting to develop a longer-range Agni missile, which will be called Agni III. This missile is believed to have a possible range between 3,500–5,000 km with a 1,000 kg warhead. According to some sources, one possible option for the Agni III would be to modify the Agni II by adding an additional booster with 36 tons of propellant.

Sagarika SLBM

India is also developing a submarine-launched ballistic missile with Russian assistance. This missile reportedly will have a range of approximately 320 km and is intended to be launched from the "Advanced Technology Vessel" nuclear submarine.

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64 Carnegie Non-Proliferation Project; quoted in Jocck, "Nuclear Relations in South Asia," p. 139.
68 Proliferation: Threat and Response, p. 25.
Space Launch Vehicles

Finally, India has also made a number of much longer-range rockets, which could be used as the basis for longer-range ballistic missiles. The Augmented Space Launch Vehicle (ASLV) is a second-generation rocket, which successfully put a spacecraft into a 450 km orbit in 1992. It is a five-stage rocket, and uses solid fuel for all stages. If this rocket were used as a ballistic missile, it is estimated that it would have a range of 4,000 km. The ASLV program led to other, more advanced, rocket projects: the Polar Satellite Launch Vehicle (PSLV) and the Geosynchronous Satellite Launch Vehicle (GSLV).

The PSLV is a four-stage rocket with "solid-fuel first and third stages, liquid-fuel second and fourth stages, and six solid-fuel strap-on boosters." In 1996, this missile placed a 1,770 lb remote-sensing satellite into a 900 km orbit. The GSLV has not been tested yet, but if it is successful it will be significantly more powerful than the PSLV. It appears to be a two-stage rocket with the same first-stage as the PSLV (but the PSLV’s strap-on boosters will be replaced by four more powerful boosters derived from the PSLV’s second stage). The GSLV’s second-stage will use a cryogenic rocket engine purchased from Russia. Both the PSLV and GSLV could be converted into intercontinental-range ballistic missiles. If they were converted into missiles, the PSLV would have a range of at least 8,000 km, and the GSLV would have a range of 14,000 km. All the SLVs would be powerful enough to carry nuclear warheads.

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71 Ibid. It is not clear whether the liquid fuel in the second and fourth stages of the PSLV is the same liquid fuel as the Prithvi.
72 Ibid.
73 Ibid.
Table 5.2: Indian Ballistic Missile Capabilities

<table>
<thead>
<tr>
<th>Land-Based Missiles</th>
<th>Range (km)</th>
<th>Payload (kg)</th>
<th>Technological Characteristics</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prithvi (Army)</td>
<td>150</td>
<td>1,000</td>
<td>Single stage, liquid fuel, road mobile</td>
<td>1994 Army ordered 75 of which 20–50 have been delivered to the 333rd regiment.</td>
</tr>
<tr>
<td>Agni</td>
<td>2,500</td>
<td>1,000</td>
<td>Two stage, liquid and solid fuel, first stage uses SLV-3, second Prithvi I</td>
<td>Tested to a range of 1,400 km. Successfully validated India’s reentry vehicle technology and basic guidance systems.</td>
</tr>
<tr>
<td>Agni II</td>
<td>2,500–3,000</td>
<td>1,000</td>
<td>Two stage, solid fuel, rail mobile</td>
<td>Test to a range of 2,000 km on April 11, 1999 and January 17, 2000; 20 missiles under order to be deployed by the end of 2001.</td>
</tr>
<tr>
<td>Agni III</td>
<td>3,500</td>
<td>1,000</td>
<td>?</td>
<td>To be developed using PSLV technology.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sea-Based Ballistic Missiles</th>
<th>Range (km)</th>
<th>Payload (kg)</th>
<th>Characteristics</th>
<th>Comments</th>
</tr>
</thead>
</table>

**Pakistani Ballistic Missiles**

Pakistan has made significant progress developing and producing ballistic missiles, largely through foreign assistance, primarily from China and North Korea. Although China pledged in 1996 to stop assisting Pakistan’s nuclear and missile programs, according to the U.S. CIA’s semi-annual report to Congress, Chinese proliferation to Pakistan actually increased since the 1998 nuclear tests. On November 21, 2000, however, China formally committed to stop exporting missile components forbidden by the Missile Technology Control Regime (MTCR).

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55 Although the Carnegie Non-Proliferation Project indicates that the Dhanush might possibly be solid-fueled, the U.S. Department of Defense indicates that the Dhanush is similar to the Prithvi II, which is believed to be liquid-fueled. Cf. table prepared by Carnegie Non-Proliferation Project, quoted in Joeck, “Nuclear relations in South Asia,” p. 139 and Proliferation: Threat and Response, p. 25.

56 Sawhney, “Pakistan Scores Over India,” p. 35.

If China abides by this commitment, it would significantly slow Pakistan's ballistic missile programs. The following discussion summarizes Pakistan's current missile capabilities.

**Hatf-I**

Pakistan has developed and produced this short-range ballistic missile, which has a range of 80 km with a payload of 500 km. This missile was reportedly developed with Chinese assistance and was first tested in 1989. It is now deployed with the Pakistani army.

**Hatf-II, Hatf-III (M-11)**

Between 1991 and 1994, Pakistan received 84 M-11 short-range ballistic missiles from China. This nuclear-capable missile reportedly has a range of 290 km with an 800 kg payload. According to some reports, these missiles are currently stored at the Sargodha Air Force Base. A missile production unit was reportedly set up at Fateh Jung with Chinese assistance. In early 1997 some of these missiles, now called the Hatf-II, were reportedly made operational and deployed with the 155 Composite Rocket Regiment of the Second Army Artillery Division, Attock. Pakistan will also reportedly base its Hatf-III missile on this design.

**Shaheen-I**

Pakistan has also developed the solid-fueled, road-mobile Shaheen-I SRBM, which was successfully flight-tested in April 1999. According to Pakistani officials, this missile has a range of 750 km and is nuclear capable. Some U.S. analysts have concluded from still photos and video released by Pakistani that the Shaheen-I is a Chinese M-9 SRBM and that the Shaheen Transporter Erector Launcher (TEL) is a modified version of the Chinese M-11 TEL.

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78 *Proliferation: Threat and Response*, p. 30; Table prepared by Carnegie Non-Proliferation Project, quoted in Joeck, “Nuclear Relations in South Asia,” p. 140.
79 Table prepared by Carnegie Non-Proliferation Project, quoted in Joeck, “Nuclear Relations in South Asia,” p. 140.
80 *Proliferation: Threat and Response*, p. 30.
81 Sawhney, “Pakistan Scores Over India,” p. 35.
82 Ibid., p. 35; see also table prepared by Carnegie Non-Proliferation Project, quoted in Joeck, “Nuclear Relations in South Asia,” p. 140.
83 Sawhney, “Pakistan Scores Over India,” p. 35.
84 Ibid., p. 35.
85 *Proliferation: Threat and Response*, p. 30.
86 Ibid.
Shaheen-II

Pakistani officials have stated that a longer-range Shaheen-2 is currently under development. According to some reports, a pair of Shaheen-II ballistic missiles were displayed during the Pakistan Day parade in Islamabad on March 23, 2000. One of the missiles was carried on a 12-wheel Transporter Erector Launcher, while the other missile was carried on a Missile Transporter. During the parade, it was claimed that the Shaheen-2 surface-to-surface missile had a range of 2,000 kilometers. Some U.S. analysts have concluded that the Shaheen-2 is a Pakistani version of the Chinese M-18 (also called the DF-15), which is reportedly a two-stage, solid-fueled missile with a range of 1000 km and a 400-500 kg payload.

Ghauri

This road mobile, nuclear-capable missile has (at its longest) a range of 1,500 km. When launched toward India (roughly south), it would have a range of 950 km. Successfully tested in April 1998 and 1999, this missile is widely accepted to be North Korea's No Dong MRBM. According to some reports, China might have provided missile guidance technology (an area where North Korea is known to be weak) and other forms of assistance in support of the Ghauri program. Although Pakistani officials have claimed that the Ghauri has a range of 1,500 km and is capable of carrying a 700 kg payload, its range is probably 1,300 km, the range of the No Dong.

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89 Ibid.
93 Proliferation: Threat and Response, p. 30.
96 Ibid., p. 30.
<table>
<thead>
<tr>
<th>Type</th>
<th>First Tested</th>
<th>Range (km)</th>
<th>Payload (kg)</th>
<th>Technological Characteristics</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-11</td>
<td>mid-1990</td>
<td>290</td>
<td>800</td>
<td>Single stage, solid fuel</td>
<td>30+ stored in canisters at Sargodha Air Force Base near Lahore; some possibly deployed in 155 Composite Rocket Division of the Second Army Artillery Division.</td>
</tr>
<tr>
<td>Hatf-I</td>
<td>Apr. 1988</td>
<td>80</td>
<td>500</td>
<td>Single stage, solid fuel</td>
<td>Developed with Chinese assistance.</td>
</tr>
<tr>
<td>Hatf-II</td>
<td>Apr. 1988</td>
<td>300</td>
<td>500</td>
<td>Single stage, solid fuel</td>
<td>Discontinued. Chinese M-11 now possibly renamed as Hatf-II.</td>
</tr>
<tr>
<td>Shaheen-II</td>
<td>Under development</td>
<td>1,000</td>
<td>400–500</td>
<td>Two-stage, solid-fuel, road mobile</td>
<td>Possibly a version of the PRC M-18.</td>
</tr>
<tr>
<td>Ghauri</td>
<td>Apr. 6, 1998</td>
<td>1,500</td>
<td>700</td>
<td>Single stage liquid fuel, road mobile</td>
<td>Tested to 1,100 km. North Korean No Dong MRBM</td>
</tr>
<tr>
<td>Ghauri II</td>
<td>Apr. 14, 1999</td>
<td>2000</td>
<td>1,000</td>
<td>Single stage liquid fuel</td>
<td>Tested to 1,165 km.</td>
</tr>
</tbody>
</table>

**Expected Deployment Systems**

Both India and Pakistan are believed to have designed nuclear gravity bombs that could be delivered by aircraft. In both countries these weapons are generally believed to be stored unassembled. According to a recent assessment by the U.S. Department of Defense, India could assemble and deploy a few nuclear weapons within a few days to a week, while Pakistan could probably assemble its weapons “fairly quickly.” Some scholars, however, have speculated that India and Pakistan possibly have some assembled nuclear weapons as well. During a crisis, the nuclear components would presumably be assembled and loaded onto bombers.

As we have seen, both countries are also developing ballistic missiles as possible delivery vehicles for their nuclear weapons. While India is probably still not able to deploy warheads on

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98 Proliferation: Threat and Response, pp. 23, 27.
its missiles, it may be able to in the future.\textsuperscript{100} India's August 1999 draft nuclear doctrine shows that India is moving toward weaponization and deployment of significantly more advanced weapon systems. This doctrine lays the foundation for a "survivable" arsenal of several hundred warheads deployed on missiles, aircraft, and ships; "robust" command-and-control procedures and technologies; nuclear weapons stored in a high state of alert; and even a space-based early-warning system.\textsuperscript{101} This draft doctrine has not been officially accepted or rejected by the Indian government.\textsuperscript{102} Whether or not India adopts this specific doctrine, the current direction of India's nuclear policy is clearly toward deployment and more advanced weapons systems.\textsuperscript{103}

If India does deploy nuclear warheads on missiles, Pakistan is likely to follow suit, to the extent that it can.\textsuperscript{104} Due to the vulnerability of its nuclear weapons to a conventional or nuclear attack from India, Pakistan will probably adopt a mobile missile system.\textsuperscript{105} Both Pakistan's liquid-fueled Ghauri and solid-fueled Shaheen missiles feature mobile launchers, and it is likely that if Pakistan chose to deploy nuclear warheads on these missiles, they would be deployed in mobile configurations.\textsuperscript{106} These systems increase the survivability of the nuclear forces, but they significantly increase command-and-control difficulties. It is also quite possible that Pakistan will need to pre-delegate the authority to launch the nuclear weapons.\textsuperscript{107} Such a pre-delegation would increase the likelihood of unauthorized or inadvertent use, as greater numbers of people are authorized to use the nuclear weapons.

Some recent accounts have questioned India's missile capabilities, however. According to \textit{Jane's Intelligence Review}, Indian security experts are questioning the effectiveness of

\begin{footnotesize}
\begin{enumerate}
  \item Proliferation: Threat and Response, pp. 23.
  \item Howard Diamond, "India Releases Nuclear Doctrine, Looks to Emulate P-5 Arsenals," \textit{Arms Control Today}, vol. 29, no. 5 (July/August, 1999), p. 23. For the text of the doctrine, see "India's Draft Nuclear Doctrine," \textit{Arms Control Today}, vol. 29, no. 5 (July/August, 1999), pp. 33-34.
  \item Nevertheless, the Indian Army Chief, General Sunderajan, stated on January 16, 2001 that the army at least is proceeding as if the draft doctrine were official policy, including weapon deployment and a nuclear triad. See "Indian Army Chief Plans Nuclear-Proof, Hi-Tech Force." \textit{The Asian Age}, January 6, 2001, pp. 1-2 in FBIS-CHI-2001-0116.
  \item Zhara, "Pakistan's Road to a Minimum Nuclear Deterrent," p. 10.
  \item Bowen and Wolvén, "Command and Control Challenges in South Asia," p. 31.
  \item Ibid., p. 33.
\end{enumerate}
\end{footnotesize}
indigenously developed and produced Agni and Prithvi missiles.\textsuperscript{108} Other analysts have argued that Indian warheads will not be able to be deployed on missiles without further testing.\textsuperscript{109} If these assessments are correct, then Pakistan's missile capability is probably more advanced than India's, because Pakistan has reportedly relied upon foreign warhead and missile designs, which have already been successfully tested.\textsuperscript{110} But it is important not to underestimate India's missile capabilities. Recent assessments by Indian think tanks and defense panels have reportedly urged speeding up India's indigenous missile programs.\textsuperscript{111} In addition, Russia has reportedly been helping India with its missile program.\textsuperscript{112}

Before we can know for certain what weapon deployments India and Pakistan will adopt, if any, we have to wait and see what actions India takes. India does appear to be pushing for some kind of weapon deployment, but whether nuclear weapons will be deployed on missiles depends on what India's missile capabilities really are.

Nuclear Command and Control Structures in India and Pakistan

\textit{Nuclear Command Structures}

Neither India nor Pakistan has a well-established command-and-control network for its nuclear weapons. In India, the civilian government and the nuclear establishment still maintain exclusive control over Indian nuclear weapons. The military has recommended that a National Command Authority be established as a high-level command institution, with a National Strategic Nuclear Command reporting to it and comprising military and technical personnel.\textsuperscript{113} But this proposal has yet to be accepted by the government. Indeed, there currently is no formal structure for nuclear decision-making in India. Although India created the National Security Council (NSC) in April 1999—a body comprised of top ministers and intended to plan long-

\textsuperscript{108} Jane's Intelligence Review, November, 2000.


\textsuperscript{113} Joeck, "Nuclear Relations in South Asia," p. 141.
range nuclear strategy, it has never met. According to K. Subrahmanyam, the convener of India’s National Security Advisory Board, the NSC is “stillborn.” If this is the case, then nuclear policymaking remains controlled by a few top politicians and the nuclear establishment.

The tightly-controlled nature of the command structure in India can potentially lead to serious difficulties. The Indian military is currently completely excluded from engaging in any strategic nuclear planning or preparations for ensuring adequate command and control if the nuclear weapons were to be transferred to the military. If nuclear weapons were to be transferred to the military during a crisis, the risks of accidental, unauthorized, or inadvertent use could be quite high. These risks will be discussed in greater detail below.

Moreover, tightly-controlled decision-making can cause leaders to make mistakes and carry out actions that are not properly thought through. According to Neal Joeck, “Excessively-controlled decision-making also poses potential problems. The Brasstucks exercise, for example, was planned by a small circle of officials who apparently did not carefully consider how Pakistan would respond to such a massive show of force. This restricted decision-making was followed by Prime Minister Rajiv Gandhi’s exclusion from the loop when the issue reached crisis proportions.”

Finally, India’s tightly-controlled command structure could cause serious difficulties if anything were to happen to the few people in charge of nuclear decision-making. The lack of an adequate Indian command structure was highlighted in October 2000, when Indian Prime Minister Atal Behari Vajpayee underwent knee surgery. During the surgery, the one person known to be authorized to launch India’s nuclear weapons was temporarily put out of commission.

Pakistan created a National Command Authority (NCA) in February 2000, following India’s creation of the NSC, to facilitate the command and control of its nuclear weapons. The NCA is reportedly comprised of two committees, the Employment Control Committee (ECC) and the Development Control Committee (DCC). The Army chief and head of the military

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114 "India’s Nuclear Dilemmas," *Economist*, p. 45.
116 In particular, see the sections “Accidental Use” and “Unauthorized Use” below.
117 Joeck, “Maintaining Nuclear Stability in South Asia,” p. 31. See also Bajpai et al., *Brasstucks and Beyond*, p. 88.
119 Shakil Shaik, “Pakistan’s National Command Authority To Control All Strategic Organizations,” *The News*
regime (currently General Pervez Musharraf) will head each of the committees. Other members of the Employment Control Committee will be the ministers of foreign affairs, defense, and interior, the chairman of the joint chiefs of staff committee, and the chiefs of the armed forces. The DCC will include the chairman of the joint chiefs of staff committee, the chiefs of the armed forces, and a "representative of the strategic organization and scientific community." On November 28, 2000, all strategic organizations, including the Khan Research Laboratories, the National Development Complex, and the Pakistan Atomic Energy Commission, were placed under the control of the NCA.

The organization of the NCA is dominated by high-level members of Pakistan’s military, and it is generally assumed that the military controls Pakistan’s command-and-control structure, as well as its entire nuclear infrastructure. As the head of both the civilian government and the military, General Musharraf presumably has the final authority to order a launch of Pakistan’s nuclear forces.

This focused command structure control has its advantages and disadvantages. Because nuclear decision-making is tightly controlled and focused, it should be fairly well-coordinated. But because the nuclear command structure is dominated by the army chief, heading the military regime, it could fall into the wrong hands if the regime were to topple. If this were to happen and the power vacuum were not filled by a stable civilian regime, Pakistan’s nuclear weapons could fall into the hands of Muslim radicals. According to Commander-in-Chief of the U.S. Central Command, General Anthony Zinni, “My worry is that Musharraf may be the last hope. We could have fundamentalists [in power] and another fundamentalist state that looks like Iran. That could be dangerous for obvious reasons. Or, we could have complete chaos and something that looks like Afghanistan.”

(Shalik, “Pakistan’s National Command Authority To Control All Strategic Organizations,” p. 1

One could argue, of course that the hands of a leader who seized power in a military coup already are the wrong hands. But the alternative could be worse, if the regime were to collapse.

The nuclear controls in Pakistan also probably would not remain as centralized as they are now, if India and Pakistan were to weaponize their arsenals. Because of the vulnerability of Pakistan’s nuclear forces to decapitation or elimination during a first-strike, Pakistan would probably choose to pre-delegate the authority to launch its nuclear forces.  

**Specific Command and Control Procedures and Technologies**

As Karl and Seng have noted, all things being equal, the smaller size of the arsenals in India and Pakistan decrease some of the risks of accidental and unauthorized use. But the size of the arsenal is not the only factor that affects nuclear controls. As we have seen in Russia, even though its controls have weakened, many of the risks of unauthorized use are reduced because many of its nuclear weapons have sophisticated use-control devices. This is not the case in India and Pakistan. Most available information indicates that neither of these countries have advanced command-and-control systems for their nuclear weapons. In particular, most assessments indicate that their nuclear weapons lack sophisticated use-control devices to prevent unauthorized use. Instead, they rely largely on the presence of guards, gates, and guns for the security of their nuclear weapons.

Because both Indian and Pakistani nuclear controls rely heavily on the “three Gs,” it is critical that they ensure that the guard forces at their nuclear facilities are reliable. As Scott Sagan notes, however, there are currently no programs in India or Pakistan to ensure the reliability of guards, civilians, and military officers at nuclear facilities. Without such programs in place, India and Pakistan run the risk that some guards or workers might steal nuclear weapons or fissile materials, or sabotage their nuclear facilities.

There is also some evidence that these countries do not place command-and-control as their highest priorities. For example, it has been reported that in order to avoid detection by spy

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125 Carranza, “Impossible Game,” p. 18.
satellites or their own security forces prior to the 1998 nuclear tests, India did not increase the security forces for guarding the nuclear weapons while they were being moved to the Pokhran test site or while they were being prepared for testing.\(^{129}\) The weapons were reportedly moved at night with only 5–6 guards per truck.\(^{130}\) While these procedures successfully avoided detection, they were potentially quite dangerous.\(^{131}\) If any of the many people involved with the procedures had alerted groups interested in obtaining Indian nuclear devices, India’s defenses would have had serious difficulties in defeating an organized attack.

India has also reportedly designed a number of nuclear devices in addition to the ones used in the 1998 tests. Moreover, because the weapons were ready for testing within a few weeks of the BJP’s election, this indicates that the weapons were probably built prior to the election. This raises questions about where these weapons were stored and how they were protected, whether only five nuclear devices were manufactured, whether other devices are ready for further tests or for weaponization and deployment, and whether these warheads are stored at locations that are secure from external attack or sabotage.\(^{132}\) Unfortunately, nothing is known for certain about how the Atomic Energy Commission is ensuring the physical safety of these nuclear devices and their components.\(^{133}\)

**Lack of Safety Cultures in India and Pakistan**

Pessimists have raised concerns that limited resources and rudimentary technologies will cause the nuclear systems in emerging NWSs to be unreliable at best, and unsafe at worst. These concerns have been specifically raised about the nuclear programs in India and Pakistan. For example, Indian scholars Praful Bidwai and Achin Vanaik have raised concerns about what they call “ramshackle deterrence” in South Asia.\(^{134}\) Citing numerous serious mishaps in the testing and designs of Indian military technology, they highlight the “disaster-prone character of a good

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\(^{133}\) Ibid., p. 6.

deal of Indian (and Pakistani) military as well as civilian infrastructure and hardware, marked as it is frequent accidents, component failures, substandard designs, poor maintenance and unsafe operational practices." They conclude that the "poor safety culture is bound to affect the working of all the hardware and software involved in any possible command, control, communications, and intelligence systems India and Pakistan may build in the future." 

**Safety of Indian Nuclear Facilities**

There is significant evidence that the Indian nuclear program has not placed safety as a high priority. Indeed, all nine of India's nuclear power reactors are among the 50 least reliable of the 399 reactors monitored by the IAEA. According to a 1996 report by India's Atomic Energy Regulatory Board (AERB), as many as 130 safety issues were identified at Indian nuclear power plants. The most serious of the safety problems identified by the AERB are at nuclear power plants located in the southern city of Madras and the western state of Rajasthan, both of which have outmoded systems for preventing a catastrophic core melt-down. According to A. Gopalakrishnan, the former director of AERB, India's Department of Atomic Energy (DAE) continually ignored the AERB's recommendations to improve the safety of India's nuclear plants. Moreover, as of April 2000, the DAE now forbids the AERB any access whatsoever to India's nuclear facilities.

According to some reports, the safety culture at India's nuclear weapons facilities is even worse than at India's nuclear power facilities. Although most information about India's weapons facilities is tightly controlled, there are nevertheless several reports of horrible problems at the Bhabba Atomic Research Center (BARC), India's primary nuclear weapons facility. For example, in 1991, the Dhruva reactor reportedly operated for almost a month with a malfunctioning emergency cooling system. And in 1995, huge amounts of water reportedly drained from the wet storage block containing submerged uranium fuel rods after an inlet hose

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135 Ibid., p. 193.
136 Ibid., p. 193.

was disconnected. If someone had not noticed the reduced water level, the radioactive fuel would have been exposed to open air, potentially causing a major disaster.\[142\]

**Similar Safety Concerns in Pakistan**

Similar concerns have been raised about the safety of Pakistani nuclear facilities as well. In 1994, Pakistan established the Nuclear Regulatory Board (NRB), which was intended to oversee safety procedures in Pakistani nuclear facilities, but it was reportedly merely an appendage of the Pakistan Atomic Energy Commission (PAEC) and therefore provided no independent oversight.\[143\] Pakistan has recently replaced the NRB with the Pakistan Nuclear Regulatory Authority (PNRA),\[144\] but the PNRA will probably provide only marginally better oversight than the NRB. Four main aspects of Pakistan's nuclear program—power generation, medical use, agricultural use, and educational facilities—remain under the authority of the military-controlled PAEC and are shrouded in secrecy.\[145\] It is therefore doubtful that PNRA can provide any coherent, independent evaluation of safety standards in Pakistan's nuclear program.\[146\]

This lack of independent oversight has raised serious concerns about the safety of Pakistani nuclear facilities. For example, the Chasma Nuclear Power Plant (CHASNUPP), which was made critical on May 3, 2000, is reportedly built in a location that some experts have warned is earthquake-prone.\[147\] Because the power plant is built on the banks of the River Indus, a major water lifeline for Pakistan, a major accident could have devastating effects on the country. Moreover, the CHASNUPP plant is based on the designs of China's Qinshan reactor, which reportedly is seriously flawed. The faulty design in the Qinshan reactor caused a serious accident in 1998 and forced the reactor to be shut down for a year.\[148\] The CHASNUPP has undergone simulation tests, but there are concerns that the tests only evaluated basic scenarios.

\[142\] Rethinaraj, "In the Comfort of Secrecy," pp. 54–57.
\[146\] Ibid.
\[148\] Ibid.
and might not have been designed to test serious design problems, such as the one that caused the failure at the Qinshan reactor.\textsuperscript{149}

There is also some reason to doubt whether Pakistan has taken the necessary measures to ensure the safety of its nuclear weapons. On April 10, 1988, a massive explosion occurred at the Ojheri ammunition depot located in a heavily populated area in the twin cities of Rawalpindi and Islamabad.\textsuperscript{150} The explosion sent heat-seeking missiles, rockets, and projectiles into population centers in both cities, causing massive destruction and hundreds of casualties. The damage caused a temporary breakdown in the telecommunications in the federal capital and at military headquarters, and caused widespread rumors of an Indian attack on the Kahuta nuclear facility, which is located nearby.\textsuperscript{151} If any of the missiles had struck the Kahuta facility, it could have caused a massive release of radioactivity in the region. While the ammunition depot did not contain nuclear weapons, it raises questions about the emphasis that Pakistan places on ensuring that its weapons are stored safely, and one must wonder whether they might take risks with their nuclear weapon storage.\textsuperscript{152}

The lack of safety cultures in India and Pakistan, while troubling in themselves, also point to more fundamental dangers that probably run through the entire nuclear programs in both countries. In particular, they justify pessimists' concerns that emerging NWSs will tend to marginalize safety and control measures in their single-minded pursuit of their weapons programs.\textsuperscript{153} India and Pakistan have demonstrated that they are willing to risk serious accidents and potential catastrophes in some parts of their nuclear programs. We cannot be at all confident that they will not run similar risks in other parts of their programs, including the safety and security of their nuclear weapons themselves.

\textsuperscript{149} Dr. Nayyar, a professor of physics at Pakistan's Quaid-i-Azam University, quoted in ibid.


\textsuperscript{151} Ibid.

\textsuperscript{152} The Ojheri explosion could also have potentially sparked an inadvertent war. See p. 232 below.

Risks of Accidental Use of Nuclear Weapons

Because both India and Pakistan reportedly store their nuclear weapons in unassembled states, the risks of accidental use are currently relatively small. But a great deal depends on whether India decides to weaponize its arsenal and deploy nuclear weapons. As the 1999 draft nuclear doctrine demonstrates, nuclear hawks in India are pushing for deployment and rapid-response capabilities. If India were to adopt this doctrine or a similar one, the warheads would be mated to its weapons. When weapons are stored in this state, the risks of accidental detonations would increase significantly. Because it is very unlikely that India has designed its nuclear weapons to allow for one-point safety, or to use insensitive high explosives (IHE) or fire-proof pits, the risks of an accidental detonation could be relatively high in the event of a fire or an accident involving a nuclear weapon (such as a nuclear weapon falling off a truck or an accident involving a vehicle carrying nuclear weapons).

In addition, because the Indian military has little, if any, experience handling nuclear weapons, the risks of accidental use could be very high during a crisis situation, at least for some time to come. If the order were given to prepare India's nuclear weapons for possible use, the military (perhaps in conjunction with India's nuclear scientists) would need to assemble the warheads rapidly; mate them to the delivery vehicles (gravity bombs or missiles); and prepare them for use, either by loading them into bombers or by aiming the missiles and preparing them for launch. All these procedures require training and precision, and it is not at all clear that the Indian military would be able to carry them out safely under extreme time constraints.

If India decided to develop a rapid-response capability, some of these dangers would be lessened, but more serious dangers would be introduced. In particular, there would be a significantly increased risk of an accidental launch of nuclear-armed missiles. India would need to engage in a great deal of additional research into safety mechanisms to prevent such an accidental launch, and it is simply not known how much effort India is devoting, or will devote, to this area. Because the Prithvi and Agni-I missiles contain a non-storable liquid fuel, it will be impossible to deploy the current configuration of either missile to allow for a rapid-response.

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155 For similar concerns about dangers arising from rapid assembly of nuclear weapons during crises, see Peter Feaver, "Neooptimists and Proliferation's Enduring Problems," Security Studies, vol. 6, no. 4 (Summer 1997), p. 115.
156 Some reports have referred to some safety features related to the nuclear triggers, but it is not clear what these safety features are, or how reliable they may be. See Chengappa, Weapons of Peace, p. 418.
This would significantly reduce the likelihood of these missiles being launched accidentally during normal circumstances, though the risks of accidental launches would probably increase significantly if they were fueled during a crisis situation. As noted, however, India has also successfully flight-tested the Agni-II missile in 1999 and 2001. Because this missile uses a solid fuel, it could be deployed in a rapid-response state. If India were to choose such a deployment option, the risks of an accidental launch could increase significantly. These risks would depend on the extent to which India integrates use-control devices into its weapons to prevent accidental launches, but there is little evidence that India is devoting significant efforts to develop such use-control devices. Furthermore, even if India intends to develop such use-control devices, if a nuclear crisis were to arise before India had developed them, it still might be tempted to mate warheads on its missiles.

It still remains to be seen what type of deployment option India would choose, if it does decide to weaponize its arsenal. According to a statement in November 1999 by India’s foreign minister, Jaswant Singh, India would not keep its weapons on a “hair-trigger alert,” though he did suggest that these weapons would be dispersed and made mobile to improve their chances of surviving a first strike. If this statement is true, then the risks of accidental launch would be relatively small during normal circumstances. But these risks would increase significantly during crisis situations, when India would presumably mate the warheads to the missiles. The fact that India has not given nuclear weapons to the military currently decreases risks of accidental use, but the transfer of nuclear weapons to the military during a crisis could dramatically increase the risks of an accident due to the military’s inexperience in handling the nuclear weapons.

What deployment option Pakistan might adopt depends upon India’s weapon deployment. It appears that if India were to adopt a rapid-response option, Pakistan would probably adopt a similar missile deployment, thereby increasing the risks of an accidental launch

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158 Statement by Jaswant Singh in The Hindu, quoted in “India’s Nuclear Dilemmas,” p. 46.
159 There is some question whether India would remain satisfied with such a deployment option, given the deployments called for in India’s Draft Nuclear Doctrine and India’s repeated statements that its nuclear weapons are also intended to deter China.
160 Because India has a no first use doctrine, they might choose to keep their weapons unmated until after a first-strike were to occur. This seems rather unlikely, however. Indeed, some reports indicate that India put its nuclear forces on alert during the Kashmir crisis. See “India’s Nuclear Dilemmas,” p. 45.
of its nuclear weapons as well. But even if India were to deploy its weapons (in field positions) without the warheads mated, concerns about survivability might nevertheless cause Pakistan to adopt a rapid-response capability. If such an event were to occur, the risks of Pakistani accidental missile launches could be very high, especially because it is unlikely that Pakistan has the technical capacity to integrate sophisticated launch controls into its missile designs.

Just as in India, it is also unlikely that Pakistan's nuclear devices are accident-proof. \(^{162}\) Because Pakistan's warheads are based on an early Chinese warhead design, they probably do not contain one-point safety designs, IHE, or fire-resistant pits. If Pakistan were to assemble its nuclear warheads, there could be an unacceptable risk of an accidental detonation of its nuclear weapons. Moreover, if Pakistan were to mate nuclear warheads to its missiles, either because it chose to establish a rapid-response capability, or during a nuclear crisis, then similar concerns would exist about accidental launches of Pakistani nuclear weapons.

**Risks of Unauthorized Use**

The current risks of unauthorized use of nuclear weapons in India and Pakistan are probably relatively small because they have a very small number of nuclear weapons that are tightly controlled by their nuclear establishments. But there are a number of factors that could increase risks of unauthorized use in the future.

As noted, although both India and Pakistan currently possess nuclear weapons that could be delivered by aircraft, and are both actively developing nuclear capable ballistic missiles, none of their weapons appear to contain sophisticated use-control devices to prevent unauthorized use. Instead, the nuclear controls in both countries appear to be based on guards, gates, and guns. As we have seen in the Russian and Chinese cases, while the “three G’s” might be sufficient during normal circumstances, they are particularly vulnerable during political, economic, and social upheavals.

The Russian case has demonstrated that severe domestic upheavals can undermine central controls and weaken the infrastructures that previously maintained the security for nuclear weapons. In particular, such upheavals can undermine the loyalty of guards and workers at nuclear facilities, especially if the state collapses economically and can no longer afford to pay the workers at its facilities. Neither India nor Pakistan appears to have taken the necessary steps

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to prevent such weaknesses from arising in their nuclear controls. Because Indian and Pakistani nuclear controls rely on the “three G’s,” and they both lack personnel reliability programs, there could be a significant risk of thefts of nuclear weapons during severe upheavals.

The Russian analogy is particularly relevant in the Pakistani case. The Pakistani state is far from stable. In the last two years, Pakistan has undergone a political coup and has been on the brink of economic collapse. The state is currently supported by foreign aid and its economy is crippled by debt payments. And there are few prospects for political and economic stability in the near future.\(^{163}\) If the Pakistani state were to fail, there could be a very great risk of a collapse in Pakistani nuclear controls. If such an event were to occur, there could be an extreme risk of thefts of nuclear weapons or of nuclear weapons falling into the hands of Islamic extremists.\(^ {164}\)

In addition, a number of fissures have been identified within the Pakistani military that could potentially undermine centralized authority.\(^ {165}\) While the custody over Pakistan’s nuclear arsenal probably remains sound under the Army chief,\(^ {166}\) one cannot assume that this will always be the case. If Pakistan were to collapse economically, or if new fissures within the military were to arise,\(^ {167}\) then the military’s central controls over its nuclear weapons could weaken or collapse.

One also cannot rule out the possibility that terrorists might choose to target nuclear facilities in India and Pakistan, especially if domestic instability were to increase. Both India and Pakistan have serious problems with domestic terrorism.\(^ {168}\) These terrorists are increasingly well-armed and have targeted critical infrastructures and military bases in the past.\(^ {169}\)


\(^{164}\) For similar concerns, see Cirincione, interviewed in “The Year 2015: The CIA Report,” *CBS Nightline*.


\(^{166}\) Ibid., p. 2.

\(^{167}\) Knowledgeable analysts have also argued that an economic meltdown could increase the prospects of major rifts within the military (Samina Ahmed, “Nuclear Weapons and Crisis Stability in South Asia,” International Security Program seminar series, Harvard University, April 20, 2001).


\(^{169}\) A few recent events vividly illustrate this point. On March 1, 2001, Pakistan’s Criminal Investigation Department reportedly seized a large number of weapons from a terrorist group in Pakistan’s Chaghai district. These weapons included five anti-tank mines and 11 missiles. On March 16, 2001, Pakistani police reportedly seized some 60 rockets from terrorists at Killi Badshah in Chaman. On April 10, 2001, “anti-national elements” planted a bomb in the parking lot of the high-security North Block in New Delhi, which houses the Home and
current defenses at both Indian and Pakistani nuclear weapons storage facilities are probably sufficient to defend against most terrorist attacks, the physical protection systems at other nuclear facilities might be less effective. Moreover, if the defenses at the most sensitive facilities were weakened by domestic upheavals, then the risks of successful terrorist attacks—either for purposes of theft or sabotage—could increase significantly.

But even if such extreme events did not occur, the tightly-controlled decision-making and rudimentary command-and-control structures in both India and Pakistan could potentially allow unauthorized use, particularly during crises. As we have seen, the Indian military is inexperienced with handling nuclear weapons. As Neal Joeck notes, "with the move from a covert to an overt nuclear status, it may be all the more important that the management of nuclear capabilities not be excessively compartmentalized, in order to ensure against accidental or unauthorized use. Keeping the military ignorant does not ensure against unauthorized use. It only guarantees that if and when nuclear capabilities are handed over to military units—in a crisis, most likely—they will be no better prepared to use the weapons than they would be to avoid using them." Moreover, because India lacks a clearly-defined nuclear doctrine and established communication channels, if the nuclear weapons were given to military during a crisis, there would a fairly high risk of unauthorized use arising from confusion or miscommunication. These concerns will probably remain for some time to come. If, however, India transfers its weapons to the military, establishes a clear use-doctrine, and develops reliable communication channels, then these specific risks could eventually be improved, depending on the training the military receives and the degree of professionalism among the troops.

Because Pakistan is currently under military rule, and its nuclear weapons are controlled by the military, one would expect a better coordination of nuclear decision-making and command-and-control systems. Nevertheless, there are also serious problems with Pakistani

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Finance Ministries. On May 2, 2001, a bomb was discovered in a park in the heart of the capital. And on May 10, 2001, suspected militants set off two bombs within a gap of minutes. One bomb detonated in the high-security Sena Bhawan Complex, which houses the army headquarters, and the other detonated behind South Block, where the Prime Minister's office is located. For a discussion of these incidents, see “Blasts Rock Army HQs,” The Nation (New Delhi), May 10, 2001; “Pakistan Police Seize Antitank Mines, Missiles, Other Weapons in Chagai District, The News (Islamabad), March 1, 2001 in FBIS-NES-2001-0304; “Police in Quetta Arrest Two Persons, Seize 60 Rockets,” The News (Islamabad), March 16, 2001 in FBIS-NES-2001-0316.


command-and-control as well. According to recent assessments, the lack of an explicit nuclear doctrine, combined with inadequate C3I, could increase the risks of unauthorized use during crises: “there is no enunciated nuclear doctrine, nor are there decision-making and communications systems adequate for either strategic or tactical command-and-control in the nuclear environment. Nuclear targeting information could not be passed in time to be of use in a rapidly changing situation, which would increase the probability of own-troop strikes by tactical [nuclear] missiles.”

The risks of unauthorized use would increase if India and Pakistan were to deploy their weapons on ballistic missiles. Risks of decapitation and questions about the survivability of the nuclear forces would probably cause both India and Pakistan to deploy mobile systems if they were to operationalize their nuclear forces. These systems would significantly increase difficulties in command-and-control, especially because their weapons lack use-control devices. In addition, because of the risks of decapitation, Pakistan is likely to adopt a “delegative” system, where the authority to launch nuclear weapons is given to a number of military officials. As the number of people authorized to launch nuclear weapons increases, so does the risk of a use of nuclear weapons that has not been commanded by the central authorities.

Inadvertent Use

The greatest concerns have been raised about a possible inadvertent use of nuclear weapons in South Asia. The combined effects of mutual mistrust, very short flight times for missiles, continual armed conflicts along their borders, and a lack of adequate confidence-building measures (CBMs) make the risks of inadvertent use quite severe, especially during crisis situations. According to George Perkovich, a South Asia expert at the W. Alton Jones Foundation, “Kargil proved that having nuclear weapons would not deter new conflicts. It also showed that unless such conflicts themselves were prevented, the possibility of an accidental or

175 Ibid., p. 18. Insofar as India is concerned about a pre-emptive attack from China, it might also adopt a “delegative” command system.
deliberate nuclear exchange would also increase given both states’ relatively poor systems of intelligence surveillance and nuclear command and control."

Due to continual mistrust between the two countries, each would be likely to misinterpret military movements, missile tests, or accidental detonations as an impending attack by the other side. Because the runways at Pakistani air force bases could be destroyed by Indian conventional air strike or nuclear attack, India could eliminate Pakistan’s nuclear bomber capability. During an acute crisis, Pakistan might therefore be faced with a “use them or lose them” dilemma. Because the flight times of bombers is approximately 10 minutes, Pakistani leaders would have very limited time to decide whether to launch an attack before Indian bombers reached their targets.

In addition, both countries have unreliable intelligence systems, which have repeatedly misinterpreted the others’ intentions. For example, during the Brasstacks incident, Pakistani intelligence reported that India’s exercise was merely a cover for an attack and Indian intelligence overlooked the defensive nature of the Pakistani troops’ position. These intelligence failures caused each side to escalate the tensions unnecessarily. In addition, their intelligence systems have sometimes failed to detect major troop movements altogether. As we have seen, during the Brasstacks crisis, Indian surveillance planes did not detect Pakistani troops positioned at their border for two weeks. And in the 1999 Kargil war, Indian intelligence failed to detect the Pakistani invasion until after they defeated a sentry division, pushed further into Indian-controlled territory, and positioned themselves at strategic locations in the Kargil heights. These intelligence failures could have two consequences. First, if either side were surprised by comparatively benign actions (such as Pakistan’s defensive positioning during the Brasstacks crisis), it would be more likely to overreact and mistakenly conclude that an attack is imminent. And second, if one side (especially Pakistan) is confident that an invasion would not be detected at first, it might be more likely to launch attacks across the border. Each of these scenarios would greatly increase the risks of nuclear escalation.

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180 There is also some evidence that there were serious Indian intelligence failures in the 1990 Kashmir crisis. Neil Jockeck refers to a paper in which a U.S. intelligence representative “commented that it would take years for the whole story to emerge, that 1990 and 1987 represented cases of dreadful Indian and Pakistani intelligence, and that the
These dangers are increased by the crude early-warning systems employed by both countries, though particularly by Pakistan. Several incidents serve to illustrate this point. First, prior to Pakistan’s nuclear tests in 1998, Pakistan reported that it had detected an air force attack on its radars and warned that it had mated a number of warheads to its Ghauri missiles. While this report might have been circulated in order to justify their nuclear tests, circulating such a report could have caused India to mate weapons to its missiles, greatly increasing the risks inadvertent use (as well as accidental and unauthorized use).

Another, perhaps more troubling, incident occurred prior to the U.S. missile strike on Afghanistan in August 1998. The United States sent a high-level U.S. official to Pakistan because it feared Pakistan would detect the missile and interpret it as an Indian strike. Pakistan never even detected the missile, however. Scholars have pointed out that this incident emphasizes not only the U.S. concern about inadvertent nuclear war between India and Pakistan, but also that Pakistan’s early-warning system “has serious flaws, and such shortcomings are more likely to foster nervousness than calm. To the extent that they lack reliable early warning systems, India or Pakistan could base launch decisions on unreliable sources, increasing the chance of mistakes.”

But even if India and Pakistan had reliable early-warning systems, the risks of inadvertent war would still be extremely high. If Indian or Pakistani radars detected aircraft headed toward them, they would have very little time to decide what to do before the aircraft reached their targets. In addition, because there would be a great deal of uncertainty about whether attacking bombers carried conventional or nuclear weapons, the attacked side (especially Pakistan) could face a “use them or lose them” scenario and be tempted to launch a nuclear attack to ensure that its nuclear capability was not destroyed. Thus, even if India and Pakistan do not deploy nuclear weapons on missiles, the risks of an inadvertent use in these circumstances would be extremely high.

Gates mission was dispatched after highest-level U.S. intelligence assessments. These comments suggested to [Indian] authorities that something had indeed been under way which U.S. intelligence sources had discovered—but which had escaped Indian attention.” See Joeck, “Maintaining Nuclear Stability in South Asia,” p. 32.


Bowen and Wolvén, “Command and Control Challenges in South Asia,” pp. 32–33. For a similar account, see Zhara, “Pakistan’s Road to a Minimum Nuclear Deterrent,” p. 11.

Amett, “Nuclear Stability and Arms Sales to India,” pp. 9–10. Moreover, because India might be capable of destroying much of Pakistan’s rudimentary C2f network, Pakistan could fear that it faced a “use them or lose them” scenario, even if it actually did not (ibid.).
If India and Pakistan were to deploy their nuclear weapons on missiles (a scenario that is quite likely, given the vulnerability of Pakistani air fields and India's stated need for deterrence against the People’s Republic of China), the risks of inadvertent use would become even worse. Because the flight time for ballistic missiles between the two countries is less than five minutes, Indian and Pakistani leaders would have virtually no time to decide what action to take (or perhaps even to launch a retaliatory strike) before the missiles hit their targets. The psychological effect on the two countries would be tremendous. According to François Heisbourg, once theater missiles are deployed in South Asia, the strategic situation will resemble the Cuban missile crisis, except that it “would be permanent rather than temporary, would occur without adequate CI in place, and with political leadership located less than five minutes from mutual Armageddon.”

The risks of inadvertent war are further increased by the fact that India and Pakistan have minimal CBMs to decrease such misinterpretations. Even though the two sides negotiated a series of CBMs after the Brasracks crisis, neither side adheres to these agreements. For instance, although hot lines between the heads of Indian and Pakistani governments have been set up, they have rarely been used, even during times of escalated tension. What is even more troubling, when they have established CBMs, they have often violated them by giving misinformation. And there is currently little hope of improving CBMs between India and Pakistan. For a year and a half after the 1999 Kargil War, the Indian government refused to have any official contact with Pakistan until Pakistan stopped supporting terrorists in Kashmir.

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187 Proliferation: Threat and Response, p. 22. See also Perkovich, India's Nuclear Bomb, p. 281. One might expect that a crisis such as the Brasracks incident would cause each side to realize the importance of CBMs, just as the Cuban missile crisis caused the United States and the Soviet Union to establish a hotline between the two countries. The fact that India and Pakistan did not use the hotlines in the 1990 Kashmir crisis or the 1999 Kargil War is very troubling indeed.
189 For example, during the Brasracks crisis, "when the possibility of war loomed large, CBMs were mistrusted or misused by one or both sides: at crucial moments, India resisted giving information to the Pakistani side out of fear that the information might somehow be used to its disadvantage, and both sides stopped using the... hotlines after December 8." Kanti Bajpai, P.R. Chari, Pervaiz Iqbal Cheema, Stephen Cohen, and Sumit Ganguly, Brasracks and Beyond: Perception and Management of Crisis in South Asia (New Delhi: Manohar Publishers, 1995), p. 110.
190 "India's Nuclear Dilemmas," Economist, p. 46. There have been recently been some contacts at the diplomatic level, but none at the political leadership levels. On May 23, 2001, however, India did invite Pakistani Musharraf to peace talks, though at the same time it ended a temporary cease-fire in Kashmir and, within hours after the
Prime Minister Vajpayee and General Musharraf did hold their first summit meeting in July 2001, but failed to make significant progress in easing tensions after their discussion reached an impasse over the Kashmir issue. 191

The combination of these factors has created a situation where the risk of inadvertent use is extremely high. Because both sides deeply mistrust each other, they are likely to misinterpret each other’s actions and escalate tensions unnecessarily. As George Perkovich argues, the fundamental lesson of the Brasstacks crisis is that “neither Indian nor Pakistani leaders intended to wage war against each other, yet India’s exercise and Pakistan’s defensive countermeasures signaled threats that heightened the other’s insecurity and could have escalated to a war that neither wanted.”192

The accidental explosion at the Ojheri ammunitions depot in Pakistan also demonstrates how tightly controlled nuclear programs, mutual mistrust, and serious accidents can raise the risks of inadvertent nuclear war.193 In the discussion following the Ojheri explosion, top military officials admitted that the existence of the depot was known only to military dictator General Zia ul-Haq and Inter-Services Intelligence, which controlled the clandestine operation of supplying arms to the Afghan resistance. According to Ahmed and Cortright, “The combination of the three factors—the proximity of the military headquarters, the federal capital, and the Kahuta facility; the breakdown in communications; and a weak command and control structure—could have created a chain of misperception and miscalculation leading to accidental or inadvertent war. Since both Pakistan and India were nuclear capable by 1988, such a conflict could have included a nuclear dimension.”194 As it was, the incident caused widespread rumors that India had attacked Pakistan’s Kahuta nuclear facility and command-and-control centers.195 If a similar accident were to occur during an acute crisis, such as during the 1999 Kargil war, Pakistan almost certainly would have concluded that it was an attack—particularly if both sides have operational nuclear weapons.

192 Perkovich, “India’s Nuclear Bomb,” p. 281.
193 See the discussion of the Ojheri incident above, p. 222.
195 Ibid., p. 96.
Conclusions about Command and Control: Impossible Deterrence

Many of the problems we have identified relate to the lack of adequate command-and-control procedures and technologies in India and Pakistan. As we have seen, the lack of these systems makes the risks of accidental, unauthorized, and inadvertent war quite high. But even if the two countries were to establish clear command structures and develop sophisticated use-control devices and early-warning systems, it would still be impossible for India and Pakistan to maintain stable deterrence. Because the two countries share an international border, the flight times for nuclear bombers and missiles are very short. It would therefore be very difficult for the two countries to avoid the risks of accidental, unauthorized, or inadvertent use during crisis situations.

Some scholars have recommended that the United States assist India and Pakistan with their command-and-control systems in order to minimize the risks of accidental and unauthorized use. Such assistance, however, would not be advisable. First, it would run counter to U.S. NPT obligations. Such assistance would, in effect, condone the nuclear weapons programs in India and Pakistan and could therefore encourage other aspiring NWSs to develop nuclear weapons.

In addition, while such assistance would decrease some risks, it would increase others. In particular, such assistance could help India and Pakistan overcome some of the difficulties in the designs of their nuclear weapons and missile systems. It could also increase Indian and Pakistani confidence in their abilities both to prevent a crisis situation from spinning out of control and to launch their nuclear weapons rapidly if such a crisis did spin out of control. Given the history of conflict between India and Pakistan and the short flight times for delivery systems, such confidence would significantly increase the risks of inadvertent use.

The best way to minimize nuclear dangers in South Asia would be to encourage India and Pakistan not to deploy their weapons, to cap their nuclear programs, and to set the stage for an eventual withdrawal of nuclear weapons from the region. While such actions would be extremely difficult to carry out, they would be ones most likely to reduce the very real risks of nuclear war between India and Pakistan.

197 For excellent suggestions about how the United States might encourage India and Pakistan to move in this direction, see Ahmed and Cortright, “South Asia At the Nuclear Crossroads: The U.S. Policy Options,” forthcoming. This issue will be examined in greater detail in the final chapter of this dissertation.
Part II: MPC&A

Indian and Pakistani nuclear facilities

India

India has a fairly large infrastructure for producing fissile materials, including 13 nuclear reactors, uranium mines and processing plants, and facilities to extract plutonium from spent fuel.\(^98\) All of these facilities are operated by the Indian Department of Atomic Energy, and there is generally little distinction between military and civilian nuclear programs in India. India’s main nuclear weapons development establishment is the Bhabha Atomic Research Centre (BARC), which is located near Trombay.\(^99\) India’s main plutonium production reactors are the Cirus and Dhruva reactors. To produce weapons-grade plutonium, BARC converts uranium into metallic reactor fuel, irradiates that fuel in the Dhruva and Cirus reactors, then processes the spent fuel to extract weapons-grade plutonium.\(^200\) By 1999, the Cirus reactor has produced an estimated total of 240–336 kg of plutonium and the Dhruva reactor has produced an estimated 280 kg of plutonium.\(^201\)

In the 1970s, India also began research into fast-breeder reactors, which can rapidly produce weapons-quality plutonium.\(^202\) As part of this program, the Indian Atomic Energy Commission built the pilot-scale, Fast Breeder Test Reactor (FBTR) in Kalpakkam. Some analysts believe that the plutonium produced in this reactor has been used in India’s nuclear weapons program.\(^203\) The IAEC announced in 1997 that it would soon break ground for a 500-Mwe Prototype Fast-Breeder Reactor (PFBR), also located at Kalpakkam.\(^204\) India claimed that the PFBR would be completed in 2007.\(^205\)

India also has 11 nuclear power reactors, located in numerous locations across the country. (See Figure 5.1 for the locations of India’s power reactors.) Of these reactors, only

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\(^98\) Proliferation: Threat and Response, pp. 23–24.


\(^200\) Ibid.

\(^201\) Ibid.


\(^203\) Ibid.

\(^204\) Ibid. See also Koch, “Selected Indian Nuclear Facilities.”

\(^205\) Jones et al., Tracking Nuclear Proliferation, p. 112.
four are currently under IAEA safeguards.\(^{206}\) The remaining reactors could be used as sources for reactor-grade plutonium, which could be used as part of India’s nuclear weapons program. India also has several plutonium reprocessing facilities, which can extract plutonium from spent fuel produced at India’s unsafeguarded commercial reactors. These reprocessing facilities are located at Tarapur, Trombay, and Kalpakkam.\(^ {207}\) The plutonium extracted from spent fuel can be used in nuclear weapons, though this reactor-grade plutonium is not as desirable as weapons-grade plutonium, due to the low concentration of Pu-239.\(^ {208}\) India has also recently built six unsafeguarded pressurized heavy-water reactors (PHWR), Madras I and II, Narora I and II, Kakrapar I and II, which are reportedly ideal for production of high quality plutonium in spent fuel because they involve a short uranium burn-up period, which ensures a higher Pu-239 concentration.\(^ {209}\)

BARC also has the capability to enrich natural uranium to produce HEU using two ultracentrifuges, located in Mysore and Rattehali.\(^ {210}\) The HEU could be used to produce fission weapons, though India is more likely to use it to fuel a nuclear submarine, increase the yield of a hydrogen bomb, or fuel “boosted” nuclear weapons.\(^ {211}\)

Finally, New Delhi has also signed a deal with Russia to purchase two light-weight reactors, which are planned to be built in southern India.\(^ {212}\) These facilities will reportedly be under facility-specific IAEA safeguards.\(^ {213}\)

\(^{206}\) Proliferation: Threat and Response, pp. 23–24.


\(^{208}\) For an explanation of the desirability of the various “grades” of plutonium for use in nuclear weapons, see Albright et al., Plutonium and Highly Enriched Uranium, 1996 (New York: Oxford University Press, 1997), pp. 18–25.

\(^{209}\) Jones et. al, Tracking Nuclear Proliferation, p. 120, n. 18.

\(^{210}\) Ibid., p. 99.


\(^{212}\) Proliferation: Threat and Response, p. 24.

\(^{213}\) Ibid., p. 24.
Figure 1: Selected Indian Nuclear Facilities

- Narora 1 and 2, and Kakrapar 1 and 2 nuclear power reactors, not subject to IAEA inspection and therefore available to produce plutonium for nuclear weapons.
- Center for Advanced Technology (CAT). Development of laser enrichment technology.
- Bhabha Atomic Research Center (BARC). Primary location of India's nuclear weapons program, including research laboratory, plutonium production from Dhrara and Cirrus research laboratory reactors, and associated plutonium extraction plants (none subject to IAEA inspection). Pilot scale uranium enrichment plant, not subject to IAEA inspection.
- Indira Gandhi Atomic Research Center. Site of Fast Breeder Test Reactor (FBTR) and pilot-scale and large-scale plutonium extraction plants. Also location of Madras 1 and 2 nuclear power reactors—not subject to IAEA inspection and therefore available to produce plutonium for nuclear weapons.

Italicized names represent nuclear-related sites. See chart.
Pakistan

Pakistan's main uranium enrichment facility is the Kahuta facility. The facility is based on German Urenco G-1 and G-2 designs that were reportedly stolen by A.Q. Khan, the "father" of Pakistan's nuclear weapons program. The enrichment facility has an estimated 3,000 centrifuges in operation, which can produce 55–95 kg of HEU per year. The Kahuta facility may also be the site where HEU is formed into weapon cores. Pakistan also has several smaller facilities that could be used to produce HEU. The Golra Sharif and Sihala facilities, both located near Islamabad, reportedly contain small, unsafeguarded centrifuge facilities.

Pakistan also possesses a capability to produce small amounts of weapon-grade plutonium. In 1998, Pakistan announced that the Khushab reactor had started operating. This reactor could make enough plutonium for a few nuclear weapons per year. The New Laboratories at the Pakistan Institute of Nuclear Science and Technology (PINSTECH) contain a plutonium reprocessing facility. Although the facility began as an experimental-scale reprocessing plant, it was reportedly upgraded and expanded during the 1990s and is believed to be able to reprocess all the irradiated fuel produced at the Khushab reactor.

There are also several research and commercial reactors in Pakistan. Because these facilities are under IAEA safeguards, they are not currently part of Pakistan's nuclear weapons program. Nevertheless, they are a potential source of spent fuel (which could be reprocessed for the reactor-grade plutonium it contains). Two small research reactors at PINSTECH are the main centers of Pakistan's open nuclear research and development program. One of these reactors (known as PARR-1) is a 10 MW pool-type research reactor supplied by the United States in 1965, and the other (PARR-2) is a Chinese-supplied 27 kilowatt thermal pool-type reactor. Pakistan has one operating commercial reactor at Karachi. This plant is a fully-safeguarded 137 MW electric CANDU heavy water reactor, supplied by Canada. This plant became operational in 1998.

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215 Ibid.
216 Ibid., p. 1.
219 Ibid.
Figure 2: Selected Pakistani Nuclear Facilities

- **Khan Research Laboratory—Kahuta.** Large-scale uranium enrichment plant designed to produce enough weapons-grade uranium for a number of nuclear devices per year; not subject to IAEA inspection.

- **Possible uranium enrichment R&D facility/pilot plant:** not subject to IAEA inspection.

- **Missile production facility.**

- **Large plutonium extraction plant:** civil works complete; not subject to IAEA inspection. Chinese-supplied 300 MWe nuclear power reactor in early stages of construction, to be subject to IAEA inspection.

- **Nuclear test site.**

- **Canadian-supplied KANUPP nuclear power reactor:** subject to IAEA inspection.

- **50-70-MWe research/plutonium production reactor under construction:** not under IAEA inspection. If completed, in conjunction with the nearby large plutonium extraction plant at Chasma and the pilot-scale plant at Rawalpindi, the reactor could be the source of a significant inventory of unsafeguarded weapons-useable plutonium.

- **Possible plutonium enrichment R&D facility/pilot plant:** not subject to IAEA inspection.

- **Missile production facility.**

- **Large plutonium extraction plant:** civil works complete; not subject to IAEA inspection. Chinese-supplied 300 MWe nuclear power reactor in early stages of construction, to be subject to IAEA inspection.

- **Italicized names represent nuclear-related sites. See chart.**
Fissile Material Production Capacities and Current Stockpiles

Because India and Pakistan have never provided independent confirmation, there is a great deal of uncertainty about their current stockpile sizes. Current estimates of India’s fissile material stockpile are based on the production capability of weapon-grade plutonium in the Cirrus, Dhruva, and power reactors (subtracting estimates of the materials used in the nuclear tests, production losses, and civil-uses of the weapon-grade plutonium). These estimates conclude that India’s fissile material stockpile was probably somewhere between 240 and 395 kilograms of weapons-grade plutonium at the end of 1999, with the median estimate being 310 kilograms. This stockpile is estimated to allow for approximately 65 nuclear weapons.

Unlike India, Pakistan’s nuclear weapons reportedly contain HEU, rather than plutonium. Although Pakistan reportedly declared a moratorium on its production of HEU in 1991, it is generally assumed that it has resumed full-scale production of HEU since the 1998 tests. A. Q. Khan, the father of Pakistan’s uranium enrichment program, also announced soon after the tests that Pakistan had never stopped producing HEU, though this claim has been greeted skeptically. Whether or not Pakistan stopped producing HEU in 1991, however, does not make a significant difference in the size of Pakistan’s current HEU stockpile, because Pakistan was accumulating a large quantity of low-enriched uranium (LEU) during this period and would have been able to further enrich the LEU fairly rapidly. Thus, even if Pakistan did cease HEU production in 1991, it probably has the roughly same amount of HEU now as it would have had if it never stopped producing HEU. According to current estimates, Pakistan had somewhere between 585 and 800 kilograms of weapons-grade uranium at the end of 1999, with a median estimate at 690 kilograms. This amount of HEU is estimated to be enough for approximately 39 nuclear weapons.

In 1998, Pakistan announced that the Khushab reactor had started operating. This reactor gives Pakistan the capability to produce enough weapons-grade plutonium for a few nuclear weapons per year. Because the reactor probably did not operate well during its early period,
however, it is only estimated to have produced approximately 5.5 kilograms of weapons-grade plutonium by the end of 1999.

Both countries are believed to be trying to increase their fissile material stockpiles as rapidly as possible. As part of this effort, India may be considering using its civil power reactors to increase its stock of weapons-grade plutonium. In addition, it is possible that India might use reactor-grade plutonium for its nuclear weapons. Some assessments suggest that one of the devices tested in 1998 used reactor-grade plutonium, though these assessments are contested. If India were to use reactor-grade plutonium in its weapons, its stockpile would be significantly larger than previously estimated. India is estimated to have approximately 800 kg of unsafeguarded separated reactor-grade plutonium and 3,400 kg of unsafeguarded reactor-grade plutonium that is not separated from spent fuel.

**MPC&A Systems at Indian and Pakistani Nuclear Facilities**

While there is very little available information on Indian and Pakistani fissile material controls, there is reason to conclude that their fissile material security systems lack adequate MPC&A technologies. Indeed, according to high-level U.S. government officials, India and Pakistan largely rely on institutional structures for the security of their fissile materials, rather than sophisticated MPC&A systems. The following is as precise a description of Indian and Pakistani fissile material security as possible, given the scarcity of open-source information on these systems.

**Physical Protection**

There is fairly strong reason to conclude that Pakistan does not have modern physical protection systems at its indigenous nuclear facilities. For instance, at a 1997 conference on MPC&A, the Pakistani representative discussed at length the military defenses at Pakistan’s primary uranium enrichment facility at Kahuta. These defenses include extensive military forces and surface-to-air missiles to defend against an Indian air strike. But he was completely silent

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224 Ibid., p. 1.
225 In sophisticated weapon designs, reactor-grade plutonium is just as effective as weapons-grade plutonium. In somewhat less sophisticated devices, easily within the capability of India and Pakistan, it is possible to make nuclear weapons with yields of roughly 20 kT range. See 1997 DOE document.
227 Ibid., p. 3.
228 Interviews by author, November 15-18, 2000.
about any advanced security systems, portal monitors, or access-control systems at the facility, which are essential elements of modern MPC&A systems. Similarly, in a speech at the 2001 Carnegie International Non-proliferation Conference, the Pakistani foreign minister stated that Pakistan has "administrative and legal mechanisms," and "institutional controls" over fissile materials, but did not mention any technological means for controlling the materials. In the absence of evidence to support a different conclusion, we cannot assume that sophisticated physical protection systems exist in Pakistan.

There are several additional reasons to doubt that Pakistan has developed these MPC&A technologies. First, it is unlikely that Pakistan has the technological or industrial capability to produce the equipment necessary for a sophisticated MPC&A system on its own. As we saw in Chapter 3, without an established technological infrastructure, Russia has had significant difficulty building indigenous portal monitors and nondestructive assay equipment, and it is likely that Pakistan would have similar difficulties. Second, Pakistan would have been unable to buy this equipment from any of the industrial countries that do produce MPC&A equipment. Because this equipment would be incorporated into Pakistan's nuclear program, none of the participants in the Nuclear Supplier's Group would be allowed to sell it to Pakistan. And finally, due to the assistance that Pakistan received from China in most aspects of its nuclear program, including the designs of its nuclear facilities, there is reason to suspect that Pakistan's fissile material controls on its indigenous facilities would closely resemble China's, which are generally based on the "three G's." 

Pakistan does have several nuclear facilities that are under IAEA safeguards, however. These facilities presumably have more sophisticated MPC&A systems that probably meet IAEA standards. For example, the KANUPP reactor, used for civilian power, is currently under Canadian-IAEA safeguards, which were left in place after Canada withdrew assistance on the reactor. Another reactor under IAEA safeguards is the CHASNUPE reactor, currently being installed with Chinese assistance. It will reportedly possess Chinese-IAEA safeguards.

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231 For a discussion of China's aid to Pakistan's nuclear program, see David Albright and Mark Hibbs, "Pakistan's Bomb: Out of the Closet," Bulletin of the Atomic Scientists, vol. 48, no. 6 (July--August, 1992), pp. 38--44.
Some analysts have also raised serious concerns about the physical protection systems at Indian facilities. In 1988, Paul Leventhal and Brahma Chellaney argued that “there is an urgent need for upgrading physical protection systems at dozens of nuclear reactors, laboratories, fuel fabrication and reprocessing plants, and research institutes scattered across India.”\footnote{233} India’s MPC&A technologies may have improved somewhat since then, since its facilities reportedly include intrusion alarms, portal monitors, and multiple-layered access controls.\footnote{234} According to one report, Indian facilities include the following physical protection measures:\footnote{235}

- When necessary (depending on the materials present), a double-barrier system is used, which is equipped with intrusion alarms and TV cameras under the control of security staff inside the facility.
- Internal security guards are not armed, but back-up is provided by special armed state police forces, which are kept at close proximity to the facility but keep a low profile. Commandos from the National Security Guard are available if needed.
- Access to such facilities is controlled by monitors, magnetic cards, turnstiles, etc. India is currently developing a fingerprint access system.
- Reprocessing plants are co-located with power plants and R&D reactors to minimize transportation risks.

Although this physical protection system sounds fairly impressive, some high-level U.S. government officials have questioned the adequacy of this system and have maintained that it probably falls short of international standards.\footnote{236} Moreover, according to A. Gopalakrishnan, the former head of India’s nuclear regulatory agency, India’s security plans do not include performance testing of this physical protection system to ensure its effectiveness.\footnote{237} Without such performance testing, it is impossible to identify or correct any weaknesses in a given physical protection system.\footnote{238} For this reason, the latest IAEA physical protection standards recommend performance testing as a critical element in physical protection systems.\footnote{239} Because

\footnote{235} Ibid., pp. 111–112.
\footnote{236} Interviews by author, November 15–18, 2000.
\footnote{237} A. Gopalakrishnan, interview by author, Harvard University, October 1, 2000.
\footnote{239} INFCIRC/225, rev. 4, section 4.4.
India has not tested its physical protection system, it could include serious defects that have simply gone unnoticed.

**MC&A**

It is also unlikely that India and Pakistan have implemented accurate material control and accounting (MC&A) systems to measure and track fissile materials moving through their nuclear facilities. According to Annette Schaper, a Senior Research associate at the Frankfort Peace Research Institute (PRIF), because the majority of their facilities were not designed with international safeguards in mind, they may lack designs that specifically facilitate an overview of material flows, provide access for taking samples, designate measurement points, contain installations that enable the application of tags and seals, and restrict human entry.²⁴⁰

As we have seen, high-level U.S. government officials have confirmed this assessment. These officials argue that India and Pakistan largely rely on institutional structures for the security of their fissile materials, rather than sophisticated MC&A.²⁴¹ Furthermore, A. Gopalakrishnan possibly gave some additional support for this suggestion, at least regarding India’s MC&A. In correspondence with the author, Gopalakrishnan recommended that the United States engage in collaborations on MC&A technologies with India.²⁴² It should probably be concluded from his statements that India’s MC&A falls short of international standards.

**Are sophisticated MPC&A systems even necessary in India and Pakistan?**

Because India and Pakistan have relatively small stockpiles of fissile materials, it is worth examining whether sophisticated MPC&A systems are even necessary in India and Pakistan. Indeed, some U.S. officials have maintained that because these stockpiles are small and tightly controlled, sophisticated MPC&A is not necessary.²⁴³ But, as I will argue, such MPC&A systems are necessary for several reasons.

First, both India and Pakistan currently produce fissile materials at several different facilities spread across their respective countries. Moreover, both India and Pakistan are building additional production facilities for producing fissile materials. Because of the diverse

²⁴² Adinarayantampi Gopalakrishnan, email correspondence with author, October 31, 2000.
²⁴³ Several U.S. officials have raised this objection to the author in private correspondence, October 27–31, 2000.
locations of these facilities, it is in fact harder to control the materials than it might seem, given the small size of their arsenals and stockpiles.

Second, it is generally believed that both countries are expanding their fissile material stockpiles as quickly as possible. As the amounts of fissile materials produced by these numerous facilities accumulate, it will be increasingly difficult to maintain the institutional controls that they have so far maintained.

The lack of safety cultures in India and Pakistan also raise questions about the adequacy of their "safeguards cultures." As we have seen in the Russia case study, unless an NWS has exerted a great deal of effort cultivating a safeguards culture, where everyone from high-level politicians to the lowest-level guard recognizes the importance of rigorous MPC&A procedures and technologies, the directors and workers at nuclear facilities are often willing to bypass security procedures in order to achieve other goals, such as meeting production schedules. A number of analysts have drawn an analogy between safety cultures and safeguards cultures, because the same motivations can undermine both. As we have seen, without independent regulatory agencies to enforce safety procedures, Indian nuclear facilities have had shoddy safety records. Indeed, A. Gopalakrishnan maintains that the physicists who measure radiation levels avoid reporting safety problems because the reports could delay production schedules. It is likely that the same constraints would prevent reporting of violations in safeguards procedures, especially because both India and Pakistan are currently trying to produce fissile materials as rapidly as possible. Although one Indian analyst has argued that an independent organization called Nuclear Material Accounting and Control (NUMAC) oversees MC&A, it is unlikely that NUMAC actually is independent of India's Department of Atomic Energy (DAE). If this is the case, then the DAE could ignore the regulations established by NUMAC, just as it has with the safety regulations established by the AERB, the agency responsible for nuclear safety.

There is also reason to suspect that Pakistan would have similar problems with the enforcement of its fissile material procedures. Because Pakistani fissile materials are controlled

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244 Albright, "India's and Pakistan's Fissile Material and Nuclear Weapons Inventories, end of 1999," p. 1.
246 Ibid., pp. 91-92.
248 See the above section: "Lack of Safety Cultures in India and Pakistan."
by the military, there is little reason to believe that any independent authority is responsible for enforcement of safeguards procedures.

Without sophisticated MPC&A systems or rigorous safeguards cultures to help track and control fissile materials, it is possible that insiders could steal these materials from Indian or Pakistani nuclear facilities. This reportedly occurred in 1994, when police in the eastern Indian state of Meghalya arrested four men for smuggling uranium. This uranium was reportedly stolen by a scientist employed by India’s Department of Atomic Energy. Officials from India’s Atomic Energy Commission later confirmed that 2.5 kg of “semi-processed” uranium, as well as 95 kg of “unprocessed” uranium, had been recovered. While it is unlikely that these materials could be used to make a nuclear device, it does indicate that some personnel at India’s nuclear facilities are willing to steal materials for sale on the black market.

Another incident, though of a different nature, occurred in India in November 2000. Indian police reportedly seized 57 pounds of uranium from a home in Hyderabad, a city in southern India, and arrested two men who had been trying to smuggle the material out of the country. The men had apparently discovered the uranium when they bought a large quantity of scrap from a local hospital. The hospital had reportedly used the material to treat cancer patients and was supposed to return the material to BARC. While this material does not appear to have been weapons-usable, it does raise serious questions about BARC’s material accounting systems, since BARC apparently did not notice that the uranium had not been returned.

Because Pakistani fissile materials are controlled by the military, it is possible that their materials are more tightly controlled than those in India. As we have seen, however, Pakistan’s fissile materials are almost certainly controlled primarily through guards, gates, and guns. But, as the Russian and Chinese cases have demonstrated, the “three G’s” can be particularly weak during political, economic, and social upheavals. Similar domestic upheavals could undermine fissile material controls in Pakistan. Although Pakistan has fewer fissile materials than Russia

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259 For similar concerns, see Leventhal and Chellaney, “Nuclear Terrorism in South Asia,” pp. 499, 465.
262 The possible weaknesses in Pakistan’s controls over fissile materials are similar to the potential weaknesses in its controls over nuclear weapons discussed above.
has, a breakdown in Pakistani fissile materials would still be very serious. Indeed, due to Pakistan’s connection with Muslim countries and terrorist groups, there might be greater opportunities for sale to groups that might be interested in obtaining fissile materials.

It is quite possible that Pakistan could undergo severe domestic upheavals in the near future. As the 1999 coup vividly demonstrated, Pakistan has had its share of political upheavals. While there is no evidence that there was any weakness in Pakistan’s controls over its nuclear weapons during the coup (especially because the military has always had exclusive control over Pakistan’s nuclear weapons), similar instances of massive political instability or coups could undermine military discipline, create fissures in the military, or cause a political collapse. Any of these scenarios could dramatically weaken Pakistan’s fissile material controls.

Moreover, as we have discussed above, the Pakistani military reportedly has a large proportion of radical Muslims and some analysts have speculated that fissures could arise in the military. If such divisions were to occur, either during Musharraf’s rule or if the military regime were to collapse, Pakistan’s controls over its fissile materials could be severely weakened or undermined completely.

Another, perhaps more likely, scenario that could undermine Pakistani fissile material controls is the collapse of the Pakistani economy. After the tests, the Pakistani economy came close to collapsing. Former-Prime Minister Sharif made matters worse by freezing the banks to prevent a run on the banks. Internal and external investment plummeted after the tests, and has never recovered. Moreover, the automatic unilateral economic sanctions by the United States weakened Pakistan’s economy further. Although the military coup was initially greeted enthusiastically, Pakistan’s economy has continued to stagnate, and poverty has increased. The International Monetary Fund is likely to approve a one-year, $580 million debt relief package, but Pakistan still faces a foreign debt of $35 billion, which is roughly half of its gross national product. If Pakistan’s economic problems were to worsen, or if its economy were to collapse completely, it is possible that a similar situation could occur in Pakistan as has occurred in Russia.

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255 Ibid., p. 786.
Part III: Conclusions

This chapter has identified a number of serious potential and actual dangers associated with the nuclear programs in India and Pakistan. Of all the cases studied in this dissertation, the risks of a nuclear exchange are probably the highest in South Asia. Over the years, India and Pakistan have had a number of nuclear crises and have fought a small-scale conventional war. Because most of the hostilities between India and Pakistan have been over the issue of Kashmir and because this issue remains unresolved, it is quite likely that the two countries will have continuing hostilities, possibly including military clashes, in the future. This situation will only become more volatile if India and Pakistan deploy their weapons on missiles. Unfortunately, both countries appear to be moving in that direction. Once their weapons are deployed in this manner, they will have created a situation where the risks of inadvertent use—and even intentional use—use could be quite possible.

Moreover, even though both countries have made significant progress in their missile programs, they appear to have made little progress in designing advanced command-and-control systems, developing and promulgating specific use-doctrines, and training their armies in procedures and techniques for handling their weapons safely. As a result, the risks of accidental or unauthorized use could be quite high for some time to come, particularly during crisis situations.

And finally, because both countries largely rely on the “3 G’s” for the controls over their nuclear weapons and fissile materials, there is little assurance they will be able to prevent insiders from stealing fissile materials or even nuclear weapons for sale on the black market. Furthermore, as we have seen, this system of controls can erode or collapse during domestic upheavals. Thus, if either country were to experience political, social, or economic upheavals, its nuclear controls could deteriorate in ways similar to the ways that the Russian system has. If such a situation were to occur, there could be great dangers of thefts of nuclear weapons or fissile materials.

Because it still remains to be seen exactly where India and Pakistan will go with their nuclear programs, it is impossible to be certain that worse-case scenarios will result. If they refrain from weaponizing and deploying their nuclear weapons or if they design and implement sophisticated C3I and MPC&A systems, establish reliable confidence-building measures and other means for improving crisis stability, refrain from deploying their weapons on missiles, and
make significant progress in resolving the Kashmir issue, they will be able to reduce or avoid some of the greatest risks identified in this study. But so far, most indications appear to be that they are not taking either of these paths. Instead, they appear to be moving toward deployed missile systems without adequate C²I systems to help reduce risks of accidental, unauthorized, or inadvertent use and MPC&A systems to help prevent thefts of fissile materials or sabotage of nuclear facilities. Thus, while India and Pakistan could eventually fix many, though probably not all, of the problems identified in this study, the situation will be likely to become significantly worse before it gets better—if it gets better at all.

Now that we have concluded the final empirical case study, we are in a position to draw together the lessons from the range of cases examined in this dissertation and relate them to the theoretical arguments presented in the proliferation optimism-pessimism debate. I will address this topic in the final chapter.
Conclusions

The evidence from the case studies examined in this project suggests that there is significant reason to be pessimistic about the further spread of nuclear weapons. In these conclusions, I return to the various arguments and predictions of the optimists and pessimists outlined in Chapter 1. Part I of this chapter examines what these case studies have taught us about the proliferation debate, and Part II discusses what the U.S. government and the international community might do to prevent the further spread of nuclear weapons and to reduce nuclear dangers among current NWSs.

Part I: Returning to the Optimist-Pessimist Debate

Assessing the Various Predictions of the Optimists and Pessimists

Optimists and pessimists each have made a number of predictions about the nuclear systems and corresponding nuclear controls that will be employed by emerging NWSs. This study has checked the various predictions against the record by assessing key aspects of the nuclear systems in NWSs. It has examined a range of cases that vary widely in their economic resources, technical capabilities, and regime types, and includes the “best case” (specifically the United States) to establish a baseline—one which itself does not unqualifiedly support the optimist position. Both sides in the debate generally agree on what criteria would determine whether or not the spread of nuclear weapons would be beneficial. As we have seen, Kenneth Waltz establishes several requirements for stable deterrence: first, NWSs must develop survivable forces; second, they must establish reliable command-and-control systems to prevent accidental and unauthorized use; third, they must avoid developing systems that require rapid decision-making, which could lead to inadvertent use.¹ In addition, for the optimist position to be convincing, emerging NWSs must develop and implement sophisticated MPC&A systems to help prevent the theft of fissile materials and the sabotage of nuclear facilities. Optimists are generally confident that NWSs will satisfy each of these criteria and are therefore confident that the spread of nuclear weapons will increase international stability. In the following discussion I will summarize the conclusions we can draw about each of the predictions made by each side in

the debate. As we will see, although the risks did vary widely among the individual cases, the accumulated evidence from these cases strongly supports the pessimist position.

**Will emerging NWSs create survivable forces?**

The evidence concerning the likelihood of NWSs developing survivable forces is somewhat mixed. On the one hand, it is very difficult to build survivable forces. The United States and the Soviet Union exerted tremendous efforts to develop systems that would be capable of surviving a first strike. These systems included resilient command and communications systems; extensive forces, deployed in rapid-response configurations that allowed for launch-on-warning; sophisticated early-warning systems; and hardened shelters for political leaders. Still, some analysts have questioned whether their nuclear forces and command structures were, in fact, survivable.²

China's nuclear forces have also been vulnerable to a first strike, since for many years, they relied on a deterrence based on an outdated ICBM force of roughly 18 missiles capable of striking the United States. Because it would require several hours of preparation with the missiles exposed before their weapons could be launched, China's forces would be highly vulnerable to a nuclear first strike by NWSs with advanced surveillance systems, such as those possessed by the United States. India and Pakistan also rely on small forces and rudimentary command and communication structures that could be destroyed by a first-strike.³ In addition, analysts have argued that a conventional or nuclear strike by India could destroy the launch strips at Pakistani air force bases, thereby eliminating or significantly weakening Pakistan's current retaliatory capability.⁴ Because it is very difficult to create survivable forces, there are risks that

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³ For example, the massive explosion at the Ojheri weapons depot in Pakistan caused a temporary breakdown in the telecommunications in the federal capital and at military headquarters (see Chapter 5, pp. 222, 232). For an assessment of the vulnerability of Indian and Pakistani military bases and command structures to nuclear or conventional first-strikes, see Eric Arnett, "Nuclear Stability and Arms Sales to India: Implications for U.S. Policy," *Arms Control Today*, vol. 27, no. 5 (August 1997), pp. 7–11, <http://www.armscontrol.org/ACT/august/arnett.html>.

⁴ Ibid., p. 9.
nuclear powers might engage in a nuclear first-strike and vulnerable nuclear powers will face a
"use them or lose them" dilemma.

On the other hand, pressures to build survivable forces are likely to cause NWSs to
develop larger and more advanced arsenals, dispersed weapon deployments, and more
complicated command structures. Of the established NWSs, the United States, Russia, Great
Britain, and France all developed these capabilities fairly early. And China appears to be
developing similar capabilities. Although China initially stored its missiles unfueled and without
the warheads mated, concerns about survivability are causing China to move to a mobile system,
where the missiles will be stored fully-fueled, possibly with mated warheads. Moreover, both
India and Pakistan appear to be moving in a similar direction. Whether or not India adopts a
system similar to the one called for in its 1999 draft nuclear doctrine, it is moving toward
weaponization, and deployment on mobile missile systems that could allow for a rapid-response
capability. Pakistan, as well, appears to be moving toward mobile systems, and might very well
adopt a rapid-response capability, a launch-on-warning policy, and predelegation of launch
authority. Thus, virtually every nuclear power so far has yielded—or is yielding—to pressures to
build larger, more robust, more complex nuclear systems, and it is reasonable to expect that other
emerging NWSs will behave similarly. Larger and more complex systems might be more
survivable (though they still might be vulnerable to a nuclear first strike), but they also
significantly increase command-and-control difficulties, as we will see in the next section.

Will Emerging NWSs develop resilient Command-and-Control Systems to Prevent Accidental and Unauthorized Use?

These case studies very clearly illustrate Peter Feaver’s arguments about the
always/never dilemma. In the early stages of their nuclear programs, the United States, the
Soviet Union, China, India, Pakistan, relied on unassembled weapons. But the pressures to build
survivable forces have led, or are currently leading, these states to move toward assembled

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5 Phillip C. Saunders and Jing-don Yuan, “China’s Strategic Force Modernization: Issues and Implications for the
United States,” in Michael Barletta, ed., Proliferation Challenges and Nonproliferation Opportunities for New
Administrations, Center for Nonproliferation Studies, Occasional Paper No. 4, September 2000, p. 41. China has
also warned that if the United States adopts a national missile defense system, it will engage in a rapid build-up of
its nuclear arsenal. See Roberto Suro, “Study Sees Possible China Nuclear Buildup,” Washington Post, August 10,

6 It must be noted that part of the reason why the United States created such a large nuclear force, especially the
large number of tactical nuclear weapons deployed in Europe, is to help provide extended deterrence—that is, to
maintain a credible nuclear deterrent for its allies as well as for itself.
weapons and dispersed deployments. These systems require advanced weapons designs and safety devices to avoid accidental detonations, and sophisticated command-and-control systems to prevent accidental and unauthorized use. From the cases in this study, there is reason to doubt that emerging NWSs will develop these advanced safety and command-and-control systems.

Accidental Detonations

Both the United States and the Soviet Union moved to systems employing assembled warheads in the early 1960s. The United States has devoted a great deal of effort to minimizing risks of accidental use, it also chose a number of deployment options, such as the continual air alert for its bomber forces, which increased risks of accidental use. As a result, the United States did have several accidents that led to accidental detonations of the high explosives in nuclear weapons, causing serious radiation dispersals (though the risks of nuclear yields resulting from these accidents were minimal). Since then, the United States has integrated numerous safety features into its weapons designs to help prevent accidental detonations, such as one-point safety, insensitive high explosives (IHE), fire-resistant pits (FRPs), and enhanced nuclear detonations safety (ENDS) systems. Nevertheless, for many years the United States retained weapons systems that did not meet its highest safety standards. In fact, several weapons systems in the U.S. nuclear arsenal reportedly still lack IHE, FRPs, and even ENDS (though these weapons systems are scheduled for de-activation in the near future).

The safety standards for Russian nuclear weapons appear to be less rigorous than those for U.S. weapons. For example, while Russian weapons do employ designs to reduce the likelihood that an accidental detonation of the high explosives would result in nuclear yields, there is some evidence to suggest that these weapons do not come close to U.S. requirements for one-point-safety. Because Russian nuclear weapons also do not appear to use insensitive high explosives, the risks that an accident could detonate the high explosives in Russian nuclear weapons—leading to radiation dispersals or even to nuclear yields—also appear higher than in

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7 For the discussion of these safety devices, see Chapter 2, p. 49 ff.
8 This fact drew serious criticism in several Congressional reviews of the safety of U.S. nuclear weapons, including the 1990 Drell Report and the 1991 Kidder Report.
9 See chapter 2, p. 54.
the United States.10 These risks of accidental detonation could further increase in the future if Russian nuclear weapons continue to age.11

While there is relatively little information on the safety devices on Chinese nuclear weapons, knowledgeable analysts have argued that Indian and Pakistani nuclear weapons lack sophisticated safety designs and safety devices necessary for preventing accidental detonations.12 Although the risks of accidental detonations of Indian and Pakistani nuclear weapons have probably been fairly small so far because they reportedly store their weapons in unassembled states, these risks could increase significantly if they carry out their plans for weaponized deployment.13

**Accidental Launches**

Overall, the current risks of accidental launches of nuclear weapons appear to be fairly small. Although the United States and Russia store their nuclear weapons in launch-ready conditions, both countries have advanced use-control devices that are highly effective in preventing accidental launches. And because China, India, and Pakistan do not currently mate their warheads to delivery vehicles, the risks of accidental launches of their nuclear weapons are also currently quite small.

Nevertheless, the risks of accidental launches of Chinese, Indian, and Pakistani nuclear weapons would be significantly higher during crisis situations, when they would presumably mate their warheads to delivery vehicles. Because none of these countries appear to employ sophisticated use-control devices for their weapons, the risks of accidental launches of their nuclear weapons would be significantly higher if they were to assemble their weapons during...

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10 For a discussion of these risks, see Chapter 3, p. 114.
11 Russia may be forced to decommission many of its weapons because they have passed their service lives, but so far it has continued to retain many of these weapons after their service lives have expired. See Paul Podvig, "Russian Strategic Forces: Uncertain Future," *Breakthroughs*, vol. 7, no. 1 (Spring 1998), pp. 11–21, <http://www.armscontrol.org/transforming/podvig.htm>; Dean Wilkening, "The Evolution of Russia's Strategic Nuclear Force," CISAC Publication: Studies in International Security and Arms Control, July 1998, <http://cisac.stanford.edu/docs/russianforces.pdf>; and "Russia's Strategic Forces Stumble," *Jane's Intelligence Review*, October 2, 2000, p. 3.
13 There have also been reports that during some crises, both India and Pakistan have assembled their weapons. Pakistan reportedly assembled at least one weapon during the 1990 Kashmir crisis and India reportedly placed its nuclear weapons on alert during the 1999 Kargil War. See George Perkovich, *India's Nuclear Bomb: The Impact on Global Proliferation* (Berkeley: University of California Press, 1999), pp. 308–309 and "India's Nuclear Dilemmas," *Economist*, vol. 357, no. 8195 (November 6, 2000), p. 45.
crises. This would especially be the case in India and Pakistan because they currently have only crude command-and-control systems and very limited experience with nuclear weapons.\textsuperscript{14}

Moreover, China, India, and Pakistan are all moving toward mobile, solid-fueled missile systems. And because of the perceived necessity for increased missile mobility, it is also quite possible that they will begin storing their missiles with their warheads mated. If new missile systems in China, India, and Pakistan are stored in this state of launch-readiness, the risks of accidental launches of their nuclear weapons could significantly increase. This is especially the case because their weapons do not appear to contain integrated launch controls similar to those used in the United States and Russia.

\textit{Unauthorized Use}

These cases have given us reason to doubt that emerging NWSs will have adequate controls to prevent unauthorized use. During the early years of their nuclear programs, every NWS we examined relied on guards, gates, and guns to prevent unauthorized use. These controls can work fairly well to prevent unauthorized use, depending on what procedures the state employs to control the weapons and whether the weapons are deployed. But as the size of the arsenal increases and as the weapons are deployed, these controls can reveal serious weaknesses.

In the 1940s and early 1950s, the United States maintained controls over its nuclear weapons through the 3G's. As the United States began deploying nuclear weapons in Europe, however, it could no longer be certain that these controls were sufficient for preventing unauthorized use. The United States eventually strengthened its command-and-control system by integrating PALs into its weapons deployed in Europe. But even then, it was not until 1996 or 1997 that it placed use-control devices on the nuclear weapons controlled by the Navy. In addition, critics have argued that procedures as the predelegation of launch authority weaken the

\textsuperscript{14} Neil Joeck, "Nuclear Relations in South Asia," in Joseph Cirincione, ed., \textit{Repairing the Regime} (New York: Routledge, 2000), p. 141; Colonel (retd.) Brian Cloughley, "Transition Time in Pakistan's Army," \textit{Jane's Intelligence Review}, April 2000, p. 26. The Indian military in particular would have extreme difficulty handling nuclear weapons if they were delivered to the military during a crisis because the military has been forbidden to handle the weapons (Joeck, "Nuclear Relations in South Asia," p. 141). It is also possible that China has not adequately trained its personnel to act under such crisis situations, since China is not believed to done the extensive training and tests that the United States and Russia have conducted (Terry Hawkins, interview by author, November 4, 1998.)
central, civilian controls over U.S. nuclear weapons, though because the military has a strong tradition of professionalism, the likelihood of unauthorized use is probably fairly small.

At first, the Soviet Union also controlled its nuclear weapons through the 3 G's. As its arsenal expanded in the 1960s, however, it began placing use-control devices on many of its nuclear weapons. But serious weaknesses in these controls arose after the Soviet collapse. It was only through tremendous efforts (and U.S. assistance) that Russia was able to consolidate the weapons deployed in Eastern Europe and the Newly Independent States to Russian territory. But the serious political and economic difficulties have continued to erode Russia’s ability to maintain central control over its nuclear weapons in the last decade. Because Russia’s main command-and-control system, the Kazbek system, is deteriorating, Russia might have to adopt a more “delegative” system, where authorization and enabling codes are distributed to lower levels in the command chain. Such a system could significantly increase the risks of unauthorized use, as larger numbers of people gained access to the launch codes for Russia’s nuclear weapons. In addition, because troops in Russia’s regional military units and the Strategic Rocket Forces are very poorly paid, there is an increased risk of nuclear coups, rebellions of regional leaders or military commanders, and thefts of nuclear weapons. Since many of Russia’s tactical weapons reportedly lack use-control devices equivalent to PALS, the theft of any of Russia’s tactical nuclear weapons could constitute a complete loss of central control over these weapons.

The Russian case also yields important lessons about possible weaknesses in Chinese, Indian, and Pakistani nuclear controls. Most evidence suggests that all three of these states rely primarily on the “3 G’s” for their nuclear controls. As the Russian case demonstrates, these systems can become particularly weak during domestic upheavals because such upheavals undermine the reliability of guard forces and personnel at nuclear facilities. While the use-control devices on most (though probably not all) of Russia’s nuclear weapons increased assurances that Russia’s nuclear controls had not collapsed, emerging NWSs will probably tend to lack such use-control devices on their weapons, especially at first. Because China, India, and

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16 Ibid., p. 27. For the risks associated with “delegative” command systems, see Feaver, “Command and Control in Emerging Nuclear Nations,” pp. 168–170.
17 See also Peter Feaver, “Neorealists and Nuclear Proliferation’s Enduring Problems,” *Security Studies*, vol. 6, no. 4 (Summer 1997), pp. 113–115.
Pakistan lack such use-control devices, if any of them were to experience serious political, economic, or social upheavals, its controls could completely collapse.

*Will emerging NWSs rely on small arsenals and simple command structures? Would these measures be sufficient for maintaining nuclear controls?*

Both Karl and Seng argue that the nuclear weapons in developing countries will be relatively easy to control, even without sophisticated use-control devices, because their arsenals will be small and their command systems simple. But there are serious problems with this argument. First, as we have seen, there is little evidence to suggest that emerging NWSs will remain satisfied with small arsenals and simple command structures. Instead, most evidence suggests that they will tend to develop larger, more complex systems, which increase organizational difficulties and will be much harder to control. As the Russian case demonstrates, complex systems can deteriorate during economic crises due to a lack of resources for maintenance and repairs.

Moreover, even if some emerging NWSs do keep their arsenals small and simple, their controls could still be severely weakened during domestic upheavals. The most serious weaknesses in Russia's controls were caused less by the size of its nuclear arsenal or the complexity of its command structure, than by the type of nuclear controls that it inherited from the Soviet Union. To be sure, the scope of Russia's problems has been exacerbated by size and complexity, but because Russia's nuclear controls relied heavily on guards, gates and guns, Russia still would have had difficulties maintaining its nuclear controls even if its nuclear system had been much smaller. Emerging NWSs probably will have problems similar to Russia's during political upheavals because they are likely to rely on the "three G's" for their nuclear command-and-control systems. Indeed, we have seen that the arsenals in China, India, and Pakistan are potentially vulnerable to accidental or unauthorized use, even though they are comparatively small.

For example, although information on the incidents that occurred during the Cultural Revolution and the Tiananmen Square crisis is incomplete, these incidents do appear to be important counterexamples to Karl's and Seng's arguments. There were several close calls in

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China during the Cultural Revolution (including what could be interpreted as an unauthorized test launch of a nuclear weapon in 1966), even though China's arsenal ranged from 20 to 100 warheads during these incidents. It is also quite possible that China could experience severe instability in the future. There are widespread reports of increasing dissatisfaction with the high levels of corruption in the Chinese Communist Party (CCP), increasing regionalist movements, and skyrocketing crime rates. These factors have led a number of analysts to argue that the regime might topple.

The prospects for political and economic stability are potentially even worse in Pakistan. Because the Pakistani economy is continually propped up with foreign loans, if its economic situation does not improve, it is quite possible that the Pakistani economy could collapse completely. If such an event were to occur, Pakistan could experience difficulties in controlling its nuclear weapons and fissile materials similar to Russia's. Although Pakistan's nuclear complex is obviously much smaller than Russia's, so are its economy, technical capabilities, organizational infrastructures, and experience with nuclear weapons. An economic meltdown could spark a host of problems, including major rifts within the military. Thus, it is possible that Pakistan could experience an even more severe breakdown in its nuclear controls than Russia has experienced if its economy were to collapse.

In addition, it is also not clear that simple command structures will significantly reduce the risks of accidental or unauthorized use, as Seng and Karl contend. Indeed, as several analysts have argued, the rudimentary command-and-control structures in India and Pakistan increase the likelihood of accidental or unauthorized use, particularly during crises. The Indian military currently does not have any experience in handling nuclear weapons. If India's nuclear weapons were given to the military during a crisis, they would be as inexperienced in preventing their use as they would be in using them. Moreover, because Pakistan currently lacks an enunciated

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19 China's arsenal had an estimated 20 warheads at the time of the 1966 test launch and had increased to roughly 100 by the time of the Lin Biao Affair in 1971 (Norris et al., Nuclear Weapons Databook, Vol. V, p. 359). China's arsenal in 1989 is estimated to have contained 433 warheads (ibid., p. 359).
nuclear doctrine, reliable decision-making or communications systems, or explicit targeting information, there is an increased likelihood that Pakistan's own troops might undertake strikes on their own.\textsuperscript{22}

As these accounts illustrate, the risks of accidental and unauthorized use could be very high in emerging NWSs, particularly during nuclear crises or periods of domestic instability. The prospects for proliferation are therefore especially disturbing because emerging NWSs will tend to be more unstable than the established NWSs have been.\textsuperscript{23}

\textbf{Will Emerging NWSs Be Likely to Avoid Inadvertent Use?}

This study has demonstrated that the further spread of nuclear weapons would probably increase the risks of inadvertent use. As we have seen, the risks of inadvertent use are relatively high among current NWSs, and there is little reason to think that emerging NWSs will avoid these risks. The pressures to build survivable forces caused both the United States and Russia to develop systems that allowed for launch-on-warning. In order to allow for LOW, they placed their nuclear weapons on permanent alert in the early 1960s, which would allow the weapons to be launched within 15 minutes from a detected attack. They also developed sophisticated early-warning systems to detect incoming nuclear attacks. As pessimists have argued, the policies of LOW require rapid decision-making, which significantly increases the risks of panic-launches due to miscalculation or false warnings.

While early-warning systems in the United States and Russia were intended in part to reduce inadvertent nuclear war by ensuring that the nuclear weapons in each country would only be used in the event of a verified attack, the early-warning systems in both countries have reportedly experienced numerous false alarms, which, combined with their LOW doctrines, could have led to inadvertent launches. Overall, the risks of inadvertent launches of either state's weapons have remained relatively small during normal, peacetime circumstances because both countries base their decisions on factors other than simply the early-warning sensors. But these risks would be much higher during crisis situations. And several false alarms also reportedly


\textsuperscript{23} For example, Lewis Dunn pointed out in 1978 that nearly half of the most likely candidate NWSs had experienced attempted or successful military coups d'état in the previous decade, and the prospects of long-term political, social, and economic stability for today's aspiring nuclear powers such as Pakistan, Iran, Iraq, and North Korea remain very questionable at best. See Lewis Dunn, "Military Politics, Nuclear Proliferation, and the 'Nuclear Coup d'Etat'," \textit{Journal of Strategic Studies}, vol. 1 (May 1978), p. 31.
occurred during crises, causing many analysts to conclude that the risks of inadvertent launches during these crises were quite high.\textsuperscript{24}

Moreover, Russia's deteriorating early-warning system, combined with its continuing deployment of weapons in a rapid-response mode, has further increased risks of inadvertent war. Because Russia's early-warning sensors are reportedly blind for several hours per day,\textsuperscript{25} Russian leaders would have very little time to decide whether or not a detected attack is real before they would need to launch their own missiles. If the Russian BMEW system continues to deteriorate, the danger of inadvertent launches would probably increase, especially if relations between the United States and Russia were to become more strained.\textsuperscript{26}

Of the cases studied, the current risks of an inadvertent launch of Chinese nuclear weapons are possibly the lowest, because China stores its missiles unfueled, with their warheads unmated. But, again, the risks of inadvertent launch would probably increase significantly during crisis situations, when Chinese missiles would presumably be fueled and the warheads would presumably be attached to the missiles. In addition, China is currently developing mobile missile systems that use solid fuel (which means they would be stored fully-fueled), and could be stored with their warheads mated. If China does choose such a deployment option, the risks of inadvertent launch could significantly increase.

The risks of inadvertent use of Indian and Pakistani nuclear weapons are probably the highest of the cases examined in this study. Owing to the rapid flight times for aircraft, India and Pakistan would have to make decisions to use their nuclear weapons with little or no advanced warning. This situation will only become more dangerous if and when they decide to deploy their weapons on missiles. Thus, the geographical proximity of India and Pakistan creates a situation where the risks of panic-launches and launches based on misinformation are extremely high. Neither country has a reliable early-warning system, but given their geographical


\textsuperscript{25} The Rumsfeld Commission concluded that Russia's current early-warning and command-and-control systems could increase risks of an inadvertent launch of Russian weapons, especially if relations between the United States and Russia were to worsen, or if Russia feared that the United States was trying to capitalize on a situation of acute civil strife in Russia (Rumsfeld Commission Report, section IIC2; Steve Maaranen, Rumsfeld Commission Staff, interview by author, May 14, 1999). See Chapter 3, p. 128 ff.

\textsuperscript{26} See Chapter 3, p. 103.
proximity, it is not even clear that early-warning systems would help reduce the risks of inadvertent launches. In addition, severe mistrust, combined with notoriously bad intelligence systems, has caused the two states to misinterpret each other’s intentions on numerous occasions.27

Thus, while the risks of inadvertent use do vary from case to case, these cases demonstrate that the risks of inadvertent use are very real. If there were a further spread of nuclear weapons, it would be likely that new NWSs would be unable to avoid the risks of inadvertent war.

**Will Emerging NWSs Develop Adequate MPC&A systems?**

Finally, we have reason to doubt that fissile materials will be adequately controlled in emerging NWSs. All the states examined in this study have relied on guards, gates, and guns for their fissile material security and controls for at least part of their nuclear history. Of these cases, only the United States moved to more advanced MPC&A systems, and only after repeated investigations identified significant vulnerabilities in this type of fissile control to insider thefts and terrorist attacks. The system of guards, gates, and guns can only work well if there is a strict authoritarian regime or a strong culture of professionalism to reinforce these controls. And, as the Russian case has vividly demonstrated, systems that rely heavily on guards, gates, and guns can break down during severe political, economic, and social upheavals. The Chinese case also demonstrates the potential weaknesses in this type of fissile material control. China’s current system is probably much stronger than Russia’s (in spite of U.S.-Russian efforts to improve Russian controls) because its political system has not yet undergone severe domestic upheavals the way Russia’s has. But China’s fissile material controls have the potential to reveal similar weaknesses to Russia’s, due to the weakening of the Chinese Communist Party, skyrocketing crime, and high levels of corruption among government officials.

Because India and Pakistan also rely primarily on “institutional controls” for their fissile materials, their fissile material stockpiles are vulnerable in similar ways. As we have seen, their nuclear facilities are vulnerable to terrorist attacks and insider thefts. Moreover, there is a significant risk that Pakistan could undergo domestic upheavals that are similar to Russia’s.

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27 For a discussion of several such incidents and their implications, see Chapter 5, pp. 199–203, 229.
Thus, the Russian model is also important for identifying the vulnerabilities in Pakistani fissile material controls.

Obviously, Russia’s MPC&A difficulties have been exacerbated by the sheer size of its fissile material stockpile, but if emerging NWSs were to divert fissile materials from indigenous nuclear reactors over a number of years into covert, or “opaque,” nuclear programs, they too could accumulate relatively large fissile material stockpiles. In addition, if they were to adopt the Soviet system of guards, gates, and guns, which does not require investment in high technology but has proven to be vulnerable during domestic upheavals, then emerging NWSs could experience the same problems with the security of fissile materials encountered by Russia. And indeed this is quite likely to happen. It is very expensive to create an MPC&A system that provides “defense-in-depth,” where the security of fissile materials is not compromised if one part of the security system fails. Emerging NWSs will often be unable to afford, or unwilling to justify the expense of, the equipment and designs necessary for resilient MPC&A systems, and thus they are likely to rely on Soviet-style MPC&A.

What is more troubling is that most of the countries examined in this study have demonstrated little interest in improving their MPC&A. In Russia, even after the United States has helped them upgrade the MPC&A at their facilities, there have been repeated instances of personnel bypassing safeguards procedures and even turning off alarm systems because they were perceived to be nuisances. China has demonstrated similar reluctance to improving its MPC&A. Chinese leaders have often argued that because China is currently relatively stable, there is no urgency in improving its MPC&A. Similar trends appear to be the case in India and Pakistan, where fissile material production is generally viewed as a higher priority than safety and safeguards. All of these countries appear to lack developed “safeguards cultures,” where

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28 For example, in 1999, India’s fissile material stockpile was estimated to be somewhere between 240 and 395 kilograms of weapons-grade plutonium at the end of 1999 and Pakistan’s stockpile was estimated to be somewhere between 585 and 800 kilograms of weapons-grade uranium. These stockpiles have almost certainly increased since then, because both countries are believed to be producing fissile materials for their nuclear weapons as rapidly as possible. See David Albright, “India’s and Pakistan’s Fissile Material and Nuclear Weapons Inventories, End of 1999,” Institute for Science and International Security Occasional Paper, October 11, 2000, <http://www.isis-online.org/publications/southasia/stocks1000.html>.


30 See Chapter 5, pp. 219–222, 244–246.
all personnel at a nuclear facility view fissile material controls as a higher priority than other objectives, such as meeting production timetables.

Because there is no evidence that emerging NWSs will view MPC&A as a higher priority than current NWSs have, it is quite likely that a further spread of nuclear weapons will increase risks that fissile materials will be stolen or diverted, and will increase opportunities for the sabotage of nuclear facilities. As a result, a further spread of nuclear weapons will tend to increase the risks of a rapid, destabilizing spread of nuclear weapons and possibly increase the opportunities for nuclear terrorism.31

Assessing the Fundamental Assumptions of the Optimists and Pessimists

As Scott Sagan correctly points out, the optimist-pessimist debate is, most fundamentally, a debate over "how best to explain and predict the behavior of states."32 The entire optimist argument rests on the premise that NWSs will always behave "rationally," or consistently act so as to maximize their self-interest.33 Because it is so clearly in the interests of NWSs to build safe, secure, and reliable nuclear systems, optimists are confident they will.34 Pessimists, on the other hand, assume that organizational, bureaucratic, and economic factors will prevent states from pursuing what could otherwise be interpreted as their "objective" interests.35 In this study, we have seen much greater support for the pessimist assumptions. The following sections will discuss the various factors that prevent states from identifying and pursuing what is in their interests.

What factors prevent states from pursuing otherwise "rational" objectives?

Organizational and Bureaucratic Constraints

In the U.S. case study, we have seen how individual organizations, such as the Department of Energy, can view certain objectives (such as meeting production timetables) as

31 For a discussion of the link between inadequate MPC&A and increased risks of rapid, destabilizing proliferation and opportunities for nuclear terrorism, see Chapter 1, pp. 14–19.
33 For a brief, but important discussion of what "rational" might mean in "rational deterrence theory," see Blight and Welch, "Risking the Destruction of Nations," p. 815, n. 12.
higher priorities than safety and security. But these constraints are much more noticeable in the other case studies. In Russia, we saw how Russian bureaucracies have often been unwilling to implement fundamental changes in fissile material controls because doing so would be admitting incompetence. In addition, the negotiation and implementation of the CTR and MPC&A programs were—and still are—often delayed by “turf battles” among various bureaucracies within Russia’s nuclear complex. Similar constraints have affected state action in China, where bureaucratic infighting limited the extent to which China was able to modernize its MPC&A system as part of the U.S.-China lab-to-lab program. These constraints are most prominent in India and Pakistan, where tightly controlled nuclear programs and lack of oversight have dramatically weakened safety and security for their nuclear systems.

**Economic and Technological Constraints**

This study has also generally supported the pessimist argument that economic and technological constraints will limit safety and security measures undertaken by NWSs. Although most observers would agree that resilient command-and-control and MPC&A systems are in the interests of every NWS, almost every one of the states examined in this study has had difficulties developing the technologies necessary for such systems. In addition, where the technologies are available on the open market, the prohibitive costs involved with the implementation of such systems have undermined the controls established by almost every state examined in this study, with the exception of the United States.

**Opacity**

Emerging NWSs will probably rely on “opaque” nuclear arsenals, especially at first, where their weapons remain untested, there are no nuclear military doctrines, there are no weapons deployed, and there is no open debate about their nuclear weapons. The cases in this study have generally supported the pessimist argument that opacity decreases both organizational

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38 Wen Hsu, “Chinese Government Restructuring: Organizational Impact on China’s Nuclear Establishment and Its Key Players in Arms Control and Nonproliferation,” *Nonproliferation Review*, vol. 6, no. 6 (Fall 1999), p. 165.

oversight and "nuclear learning" about possible flaws in weapons designs and safety measures. As we have seen, U.S. controls were often improved only after independent agencies and Congressional investigations revealed significant weaknesses in U.S. nuclear safety and security. Because emerging NWSs will tend to have opaque nuclear programs, they will be more likely to rely on unsafe weapons designs and will tend to regard safety and security as lower priorities than weapons production.

A critical examination of the nuclear programs in India and Pakistan generally supports this argument. The lack of transparency in their nuclear programs has prevented any independent oversight of safety and safeguards procedures. As a result, India continues to operate nuclear facilities with safety features that are inadequate to prevent catastrophic core meltdowns. Pakistan, as well, has had serious accidents, which have risked damaging their nuclear facilities. Because India and Pakistan have demonstrated that they are willing to risk serious accidents and potential catastrophes in some parts of their nuclear programs, it is likely that similar problems exist throughout their nuclear programs, including the safety and security of their nuclear weapons themselves. Both countries have generally attempted to hide any difficulties in these areas behind the veil of "national security interests." In addition, the lack of independent oversight of Indian and Pakistani nuclear programs make it very unlikely that either country has developed "safeguards cultures" to help prevent thefts of fissile materials from their nuclear facilities.

This study has also revealed heightened risks of war, once emerging NWSs move from opaque to "visible" nuclear programs. After their 1998 tests, India and Pakistan openly declared themselves nuclear powers and began moving toward weapon deployments. The nuclear tests and subsequent events significantly increased tensions between the two states. Since the time they became "visible" proliferants, they have engaged in a small-scale war, repeatedly issued nuclear threats (indeed, one scholar counted 15 nuclear threats issued by India and Pakistan

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40 Peter Feaver, "Correspondence: Proliferation Pessimism and Emerging Nuclear Powers," *International Security*, vol. 21, no. 3 (Fall 1997), p. 191. Opacity will necessarily have a major impact on the risks of accidental detonation of nuclear weapons. The majority of the nuclear tests in the United States and the Soviet Union were conducted to assess and improve the safety and reliability of their nuclear weapons.

41 For a summary of the safety and security difficulties in the Indian and Pakistani nuclear programs, see Chapter 5, pp. 219-222, 244-246.


43 See Chapter 5, pp. 244-246.
during the Kargil war alone), and have placed their armed forces on high alert on several occasions even after the Kargil war.14 But these actions all took place when neither state had yet established either military nuclear doctrines or command-and-control systems. As a result, the move to visible nuclear status has significantly increased instability in the region. And there is little evidence that emerging NWSs will remain satisfied with an opaque status. Of the current nuclear powers, only Israel has been satisfied with an opaque nuclear program.

Political, economic, and social upheavals

One of the most important lessons from this study is that severe domestic upheavals can seriously undermine nuclear controls. Thus, these cases reveal serious difficulties with Jordan Seng’s argument that the risk of domestic political conflict would actually cause a state’s leaders to maintain stronger controls over the state’s nuclear weapons.14 As the Russian case clearly demonstrates, severe domestic crises can create new circumstances that were not adequately foreseen. During economic, political, and social upheavals, the nuclear controls in any NWS are likely to be strained to the breaking point. Extensive economic resources and reliable manpower are required to maintain nuclear controls during such upheavals, and these are precisely what such upheavals tend to undermine.

Chinese nuclear controls have also demonstrated potential and actual weaknesses during domestic upheavals. Indeed, China experienced a number of domestic crises before it finally expressed interest in strengthening its command-and-control structure. China’s control over its nuclear weapons was relatively weak during these crises and there was a definite risk that central authorities could have lost control over Chinese nuclear weapons. Granted, there is evidence that China expressed interest in improving its command and control after the Tiananmen Square crisis, but this was only after the fact. And it is likely that China still does not have PALS on its nuclear weapons.16 The evidence from China therefore suggests that Seng is too optimistic in

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14 The Pakistani armed forces were placed on high alert after the August 10, 1999 downing of a Pakistani naval plane by Indian jet fighters and India’s armed forces were placed on high alert after the imposition of military rule in Pakistan on October 12, 1999 by army chief Pervez Musharraf. See Samina Ahmed and David Cortright, South Asia at the Nuclear Crossroads, a joint publication by the Managing the Atom Project at Harvard University, the Fourth Freedom Forum, and the Joan B. Kroc Institute for International Peace Studies at the University of Notre Dame, (March 2001), p. 33, n. 5.

15 Seng argues, “if, as pessimists worry, minor proliferators will tend to suffer from domestic instabilities, then central leaders are likely to keep nuclear control organizations as insulated and tightly held as possible” (Seng, “Less is More,” pp. 75–76).

16 See Chapter 4, p. 162.
concluding that the risk of domestic conflict will actually increase the measures a state will take to ensure control over its nuclear weapons.

_NWSs might simply not see the necessity for rigorous safety and security measures_

As we have seen, both optimists and pessimists do, or should, acknowledge that it is in the interests of every NWS to maintain safety and security for their nuclear weapons and fissile materials. And yet, the cases in this study suggest that NWSs, or certain groups within NWSs, simply may not see the necessity for rigorous safety and security measures. In particular, emerging NWSs will tend to marginalize such measures in their single-minded pursuit of their weapons programs. This is the most fundamental weakness in the optimists' arguments, since they assume that states will always clearly understand—and pursue—their interests.

For example, we have seen extensive evidence that India and Pakistan have very bad safety and safeguards cultures. Both countries have been willing to risk accidents and potential catastrophes in numerous areas of their nuclear programs, and neither state has been willing to correct these problems. The marginalizing of safety and security is not unique to India and Pakistan. For example, even after Russian facilities have encountered severe difficulties with fissile material security and the United States has assisted them with MPC&A upgrades, many facilities still do not choose to follow the procedures or use the technologies necessary for fissile material security. We have seen similar problems in China. Although Chinese officials have admitted that their fissile material controls are based on the Russian model, they have demonstrated little interest in improving their fissile material controls because, they argue, China is currently stable. But since China has had severe domestic upheavals in the past and could have more in the future, this position appears unjustified. Because it is highly unlikely that emerging NWSs would see their self-interests any more clearly than have the current NWSs, we have reason to side with the pessimist position.

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49 See Chapter 5, pp. 219–222, 244–246.

Will emerging NWSs learn the lessons of the past?

Optimists often argue, implicitly or explicitly, that emerging NWSs will avoid some of the difficulties that current NWSs may have encountered because they will learn from the current NWSs’ mistakes.\textsuperscript{51} Indeed, in the 1990s, many scholars argued that South Asia was taking a different, and arguably, a safer route than that taken by the Superpowers.\textsuperscript{52} But the events of the last two years have proven that these predictions were overly optimistic. As we have seen, both states are moving toward assembled weapon systems and much larger deployments (though their arsenals will clearly be much smaller than those of the Superpowers).\textsuperscript{53} In fact, insofar as India and Pakistan have learned any lessons from the Cold War, they have learned many of the wrong lessons. Although they have adopted the language of deterrence used in the Cold War, they have not demonstrated the same levels of restraint that the United States and the Soviet Union did. Instead, they have supported proxy wars in each other’s territories and have even gone to war with each other. If India and Pakistan are at all representative of emerging NWSs, their actions should give us little confidence that “nuclear learning” will take place in emerging NWSs.

Moreover, we have also seen strong evidence that emerging NWSs will be unlikely to learn from the lessons in Russia. In spite of the clear evidence that nuclear controls based on the “3 G’s” are highly vulnerable during domestic upheavals, China, India, Pakistan, and even Russia itself have been reluctant to adopt more advanced command-and-control and MPC&A systems. There is very little reason for confidence that emerging NWSs will be more likely to learn from Russia’s difficulties than these states have been. Rather, the evidence supports the opposite conclusion.

\textsuperscript{51} David Karl, for example, asserts that emerging NWSs will never assemble their weapons, and Kenneth Waltz maintains that emerging NWSs will be unlikely to undertake such “irrational” actions as building massive arsenals. See Karl, “Proliferation Pessimism and Emerging Nuclear Powers,” pp. 108–109; Waltz, “More May Be Better,” pp. 31–32. See also Shaun Gregory, “A Formidable Challenge: Nuclear Command and Control in South Asia,” Disarmament Diplomacy, vol. 54 (February 2001), <http://www.acronym.org.uk/54greg.htm>.


\textsuperscript{53} Indian and Pakistani officials have also claimed, unconvincingly, that they will avoid the dangers of the Cold War. For example, the Indian Army’s Chief of Staff said they “do not want to get into a situation” like “the old days of mutually assured destruction” in the very same speech where he says that India will develop thermonuclear devices and adopt the deployment system recommended in India’s Draft Nuclear Doctrine (which include a triad of 300-400 weapons deployed in rapid response configurations). See Rahul Bedi, “Exclusive Interview with General Sunderajan Padmanabhan, Indian Army Chief,” The Asian Age, January 16, 2001, pp. 1–2, in FBIS-CHI-2001-0116.
Indeed, it is much more difficult than one might think for "learning" to take place on institutional or state levels. As Jack Levy has argued, very different processes occur when an institution learns than when an individual learns.\textsuperscript{54} In particular, learning on an institutional or government level can only take place if individuals' inferences from experience become embedded in organizational memory and procedures, and this process can be blocked by any number of factors, including organizational resistance to change, and domestic, economic, or bureaucratic constraints.\textsuperscript{55} As the Indian and Pakistani cases demonstrate, all of these factors have limited the extent to which India and Pakistan have been able or willing to learn from the experiences of the other NWSs and adopt specific procedures and technologies to minimize dangers in their nuclear systems. In addition, the highly-controlled nuclear programs in India and Pakistan have prevented open debate over nuclear policies and the advantages or disadvantages of various nuclear systems, creating serious obstacles to "nuclear learning."\textsuperscript{56}

\textbf{Would These Dangers be Solved By Providing Command-and-Control Technologies to Emerging NWSs?}

Optimists have argued that many of the difficulties identified by the pessimists could be solved if the United States were to provide emerging NWSs with command-and-control technologies.\textsuperscript{57} Indeed, because a major focus of this study has been on whether or not NWSs will develop command-and-control and MPC&A technologies, it is necessary to address this contention.

There are, in fact, a number of reasons against providing emerging NWSs with technologies to help them control their burgeoning nuclear weapons programs. Setting aside such significant questions as whether emerging NWSs would be willing to provide the United States information about their weapons designs and capabilities, such a policy would be a "non-starter" among policymakers in Washington, and for good reason. First, it is doubtful that the United States would want to commit its efforts and resources to helping \textit{additional} countries solve their nuclear difficulties. The United States currently devotes over $870 million per year to

\begin{itemize}
  \item \textsuperscript{55} Ibid., p. 288-290.
  \item \textsuperscript{56} They thus support Peter Feaver's argument that "opacity inhibits a broader public strategic discourse that would increase public scrutiny of these issues and allow for a thorough examination of command-and-control problems." See Feaver, "Correspondence," p. 191.
  \item \textsuperscript{57} Karl, "Proliferation Pessimism and Emerging Nuclear Powers," p. 114.
\end{itemize}
helping Russia improve its nuclear controls. While it might be desirable to work with officially recognized NWSs such as Russia and China to improve their nuclear controls, it does not make much sense to encourage further proliferation, only to devote additional resources to helping the new NWSs in such endeavors. Second, the United States would be unlikely to be willing to help emerging NWSs develop safe weapons designs and command-and-control systems because such assistance would significantly improve their military capabilities. As Peter Feaver has argued, regardless of whether one is an optimist or pessimist in the proliferation debate, it is not in the U.S. interest to help emerging NWSs improve their nuclear capabilities. Such a policy would dramatically undermine the U.S. ability to project its power abroad and would tend to embolden other states to resist U.S. efforts to impose its will.

More fundamentally, it is also unlikely that providing such assistance would reduce many of the risks identified in this study. While improved command-and-control technologies could reduce some risks of accidental and unauthorized use, they would also tend to increase other risks. Improved command-and-control technologies could encourage emerging NWSs to deploy their weapons higher states of readiness, increasing the regional tensions and the likelihood of inadvertent and intentional use.

Advanced command-and-control technologies may also increase the confidence among emerging NWSs that they can “handle” any situation that arises, and therefore could make them more willing to engage in “risky” activities. To illustrate this case, one need only look at the 1999 Kargil war. Would advanced command-and-control technologies have reduced the likelihood of such an event occurring? The answer to this is decisively no. As it was, Pakistan invaded Indian-controlled Kashmir in 1999 because it was convinced that its nuclear capabilities would prevent a large-scale Indian retaliation. An advanced, mobile missile system, deployed in

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58 The United States appropriated $874.4 million of the FY2001 budget to the nonproliferation programs in Russia, though this funding will probably be cut in FY2002. See George Lobsenz, “Bush Whacking DOE Nonproliferation Aid To Russia,” Energy Daily, March 16, 2001.

59 Such assistance might only be desirable if it were highly demonstrable that it would be in the U.S. interest or that it would clearly increase international stability. But neither of these is certain, or even likely, as we discuss in the remainder of this section.

60 Feaver, “Correspondence: Proliferation Pessimism and Emerging Nuclear Powers,” p. 192. This is especially the case, since the United States has had tempestuous, and at times, even hostile relations with many of the states with nuclear ambitions, such as Iran, Iraq, and North Korea.

a configuration that allowed for a rapid-response capability would probably only have only emboldened Pakistan even more.

Furthermore, such assistance would also implicitly condone the nuclear programs in emerging NWSs, undermine U.S. nonproliferation commitments, and cause serious damage to the nonproliferation regime. The Nuclear Nonproliferation Treaty (NPT), the cornerstone of the nonproliferation regime, forbids such assistance. If the United States were to abandon its NPT commitments, the entire nonproliferation regime would begin to unravel. Additional states with nuclear aspirations could thus be encouraged to develop nuclear weapons. Given the risks that could result from the rapid spread of nuclear weapons, such events could seriously undermine international stability.62

The question remains, however, whether the United States should help emerging NWSs design and implement MPC&A systems. To a certain degree, such assistance would be unnecessary because many of these safeguards technologies are available from the IAEA. U.S. scientists could, however, help instruct emerging NWSs in techniques for designing and implementing MPC&A systems. But, as we have seen, there is little evidence that emerging NWSs would even be interested in developing MPC&A technologies, given the costs of such systems. For example, China has demonstrated little interest in improving its MPC&A, in spite of U.S. encouragement and willingness to work with China on this agenda, and India and Pakistan have U.S. scientists have given numerous briefings on MPC&A techniques to Indian and Pakistani scientists with little success.63

**Summing Up: Will the further spread of nuclear weapons be better or worse?**

This study has revealed numerous reasons to be skeptical that the spread of nuclear weapons would increase international stability by helping prevent conventional and nuclear wars. Because there is reason to suspect that emerging NWSs will not handle their nuclear weapons and fissile materials any better than current NWSs have, we should conclude that the further spread of nuclear weapons will tend to undermine international stability in a number of ways.

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63 John Holdren, head of the Science, Technology, and Public Policy Program at Harvard University, interview with author, Harvard University, October 2000.
First, because emerging NWSs will probably rely on inadequate command-and-control systems, the risks of accidental and unauthorized use will tend to be fairly high. Second, because emerging NWSs will tend to adopt systems that allow for rapid response, the risks of inadvertent war will also be high, especially during crisis situations. Third, because emerging NWSs will tend to adopt MPC&A systems that are vulnerable to overt attacks and insider thefts, the further spread of nuclear weapons could lead to rapid, destabilizing proliferation and increased opportunities for nuclear terrorism.

Finally, there is reason to question whether nuclear weapons will in fact increase stability. Although nuclear weapons can cause states to be cautious about undertaking actions that can be interpreted as aggressive and can prevent states from attacking one another, this may not always be the case. While the presence of nuclear weapons did appear to help constrain U.S. and Soviet actions during the Cold War, this has generally not held true in South Asia. Many analysts conclude that Pakistan invaded Indian-controlled Kargil in 1999, at least in part, because it was confident that its nuclear weapons would deter a large-scale India retaliation. The Kargil War was thus in part caused by the presence of nuclear weapons in South Asia. Thus, the optimist argument that nuclear weapons will help prevent conventional war has not always held true. Moreover, this weakness in the optimist argument should also cause us to question the second part of their argument, that nuclear weapons help prevent nuclear war as well.

Conventional wars between nuclear powers run serious risks of escalating to nuclear war.

Based on a careful examination of nuclear programs in the United States, Russia, China, India, and Pakistan, this study concludes that the optimists’ arguments about the actions that emerging NWSs will probably take are seriously flawed and thus overly optimistic. While it is impossible to prove that further nuclear proliferation will necessarily precipitate nuclear disasters, the potential consequences are too severe to advocate nuclear weapons proliferation in hopes that the stability predicted by the optimists will indeed occur.

**Part II: Policy Implications**

The theoretical discussion of the proliferation debate is not merely ‘academic’; it has direct policy implications. Because optimists understate the dangers of proliferation, they weaken support for international nonproliferation objectives, including efforts to prevent the further spread of nuclear weapons and programs designed to help current NWSs reduce
proliferation risks arising from weakened nuclear controls. The theoretical conclusions of this study indicate, however, that the United States and the international community should take further steps in precisely these areas. The case studies in this dissertation suggest a series of appropriate policies that the United States and the international community might undertake to promote these nonproliferation objectives. Because the primary objective of the present study is not to identify policy recommendations, however, the following sections will only briefly outline the general directions that U.S. and international policy should probably take, but will not discuss specific recommendations in great detail.

**Strengthen efforts to prevent a further spread of nuclear weapons**

Because nuclear proliferation is likely to be dangerous and destabilizing, it is in the interests of the United States and the international community to develop a consensus on strengthening the international nonproliferation regime and ensuring compliance with it. As part of a strengthened regime, IAEA safeguards need to be based on full and effective implementation of new and existing authorities for the IAEA, which will help prevent diversion of fissile materials from declared nuclear facilities and increase assurances that there are no opaque nuclear programs.\(^6^4\) But even if these steps are taken, many worldwide nuclear risks remain, and the United States and the international community should do what they can to help reduce these risks.

**Further cuts in U.S. and Russian nuclear forces**

A number of scholars have discussed possible ways to reduce dangers arising from the U.S. and Russian nuclear arsenals. The first steps they suggest are further reductions in the U.S. nuclear weapons program and fissile material stockpiles. Due to START I, the U.S. and Russian nuclear arsenals have both been significantly reduced in recent years. But many scholars argue that more should be done. The United States and Russia still retain large strategic forces (over 7000 on each side) and tactical weapons (approximately 1670 for the United States and approximately 10,000 for Russia).\(^6^5\) Given the risks that this study has identified, particularly

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\(^{64}\) For a summary of the additional authorities given to the IAEA, see Appendix A, p. 288.

with Russia's deteriorating nuclear controls, the United States and Russia should increase efforts for further nuclear arms reductions.

Further reductions are being discussed as part of START III, but progress on the treaty has been difficult, in part due to U.S. reluctance to reduce its strategic arsenal size beyond 2000–2500 nuclear weapons, and in part, to Russian misgivings about U.S. plans for a national missile defense (NMD). The prospects for successful negotiations on START III may be improving, however, because Russia has recently eased its stance against U.S. NMD and the two countries are reportedly exploring possible deals that could allow for the modification or abrogation of the ABM Treaty. Indeed, in a meeting after the July 2001 G-8 summit, Presidents Bush and Putin agreed to link discussions of American plans to deploy a missile defense system with the prospect of large cuts in both nuclear arsenals. The United States should therefore increase efforts to come to an agreement with Russia over these issues and possibly to negotiate a successful agreement on START III or a similar arms reduction treaty.

During his election campaign, George W. Bush stated that he plans further unilateral cuts in the U.S. nuclear force and he has recently ordered a comprehensive review of the U.S. nuclear arsenal as a first step in this direction. Such unilateral U.S. reductions might encourage Russia to make similar reductions in its nuclear forces.

The United States should also explore the possibilities for bilateral accords on the elimination of large numbers of tactical nuclear weapons in the U.S. and Russian arsenals. While the START treaties limit the re-deployment of strategic weapons, the tactical weapons

70 Some analysts have argued, however, that such unilateral U.S. reductions are not advisable because they would eliminate bargaining leverage for the United States to encourage Russia to reduce its nuclear forces.

reductions on both sides have only been limited by non-binding unilateral declarations. Because many of Russia's tactical weapons reportedly do not contain use-control devices, thefts of these weapons could very serious. Efforts to negotiate further tactical nuclear weapons reductions have reportedly not achieved much success, however, because Russia reportedly views its tactical nuclear forces as a necessary countermeasure to the recent technological breakthroughs by the United States in costly, advanced conventional arms.

**Increase Assistance to Russia**

One of the most pressing threats to U.S. and global security is the danger arising from Russia's deteriorating nuclear systems. As we have seen, the deterioration of Russia's C3I system has increased the dangers of accidental, unauthorized, and inadvertent use. One way to help reduce some of these dangers would be for the United States and Russia to establish a permanent joint early-warning center to share information about potential nuclear launches, as they discussed in the June 2000 summit meeting. Such a center could help reduce risks of inadvertent launches, especially if relations between the United States and Russia do not deteriorate. The United States and Russia should therefore renew the stalled negotiations on the subject and move toward establishing the center as soon as possible. Some analysts have also recommended that the United States provide financial and technical assistance to help Russia improve its BMEW system.

Other analysts, most notably Bruce Blair, have also recommended de-alerting U.S. and Russian nuclear weapons. Many of the risks of inadvertent launches are due to the combined effects of Russia's deteriorating BMEW system and the high alert status (or "hair-trigger" alert) of U.S. and Russian nuclear weapons. If the weapons were taken off their high alert status, then at least some of these risks would be reduced. Advocates of such proposals have suggested various ways for de-alerting the nuclear weapons, including removing warheads from missiles.

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72 For a discussion of the U.S. and Russian Presidential Nuclear Initiatives (PNIs), see Chapter 2, p. 37 and Chapter 3, p. 93.
73 Potter and Sokov, "Tactical Nuclear Weapons," p. 3.
75 For a discussion of the stalled talks over the joint early-warning center, see Chapter 3, p. 104.
and storing them separately, removing launch keys from control centers, and erasing targeting information from computer systems. These proposals are not without their critics, however. Officials in the governments and militaries in both the United States and Russia have often objected to such suggestions because they feel it would reduce security too much. Critics have also argued that de-alerting could greatly increase instability during crises, because both sides would have great incentives to engage in dangerous re-alerting of massive numbers of weapons very quickly.

Given the seriousness of the risks associated with a loss of control over Russia’s nuclear weapons and fissile materials, continued emphasis must also be placed on improving Russia’s nuclear security. The United States and the international community should therefore increase funding and support for the CTR and MPC&A programs. A recent bi-partisan report argued that current efforts in U.S.-Russian nuclear security should be expanded. The report recommended that the United States should invest $30 billion over the next 10 years in this critical area. Both the CTR and MPC&A programs are positioned to accomplish a great deal in the next several years, but there are also some significant obstacles yet to overcome.

So far, one of the biggest obstacles to progress in both programs has been the sensitivity of issues involved. As a result, U.S. personnel have been denied access to many critical sites, and have therefore been unable to determine what improvements are necessary. Most assessments of these programs have therefore stressed that improved transparency is essential for continued success.

In addition, for the CTR and MPC&A programs to be successful in the long term, they must ensure the “sustainability” of the security upgrades to Russian facilities. The reports of facilities being unable to maintain equipment once it is in place or of facilities simply being willing to bypass security procedures are very troubling indeed. There are several ways for the CTR and MPC&A programs to help ensure that security upgrades are effective in the future,

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79 Ibid., p. 16.
80 Ibid.
including promoting indigenous Russian MPC&A technologies, increasing efforts to create a safeguards culture, and providing funding for certain aspects of the operation and maintenance of the MPC&A technology until Russia can take over.83

The future direction of these projects to improve Russian nuclear security may be modified by the Bush administration, however. The Bush administration initially proposed cutting the funding for these programs in FY2002 to 12 percent below the FY2001 level and 30 percent below the figures proposed in the Clinton administration’s FY2002 budget.84 But according to recent reports, after a thorough assessment of the programs, the administration determined that most of these programs are worth retaining and may even expand some projects. While most of the projects aimed at helping Russia improve its warhead and fissile material security will continue to be funded, the White House reportedly wants to restructure or end two programs: a $2.1 billion effort to dispose of hundreds of tons of military plutonium and a program to shrink Russian nuclear cities and to provide alternative jobs for nuclear scientists. Both of these programs have been criticized in Congress.85

Explore possibilities for renewed collaboration with China to improve nuclear controls

Any accidental or unauthorized launch of nuclear weapons or any theft of nuclear weapons or fissile materials constitutes an unacceptable threat to the United States and the international community. The United States therefore has a vital interest in encouraging China to improve the command-and-control system for its nuclear weapons and the MPC&A for its nuclear facilities. The best way for the United States to pursue this interest would be to continue the lab-to-lab collaboration with China.


Increased scientific collaborations will improve the trust between the two countries on nuclear issues. This greater trust could increase transparency and mutual understanding of the nuclear establishments in the two counties. It is only from such a position of trust that the United States could hope to encourage China to improve its command-and-control structure.

The United States must ensure that its assistance in improvements to China’s command-and-control system does not also improve China’s nuclear capabilities. For example, although specific technical information about some types of use-control devices should not be given China because it would also reveal important information about U.S. warhead designs, there are a number of U.S. use-control technologies and procedures that have little to do with weapon designs. With care, the United States should be able to help China improve its command and control while still protecting its national security interests.

But perhaps even more importantly, the lab-to-lab collaborations seem to be the best way we could hope to encourage China to improve its MPC&A. As we have seen in Russia, weak MPC&A systems can increase the risks of nuclear weapon proliferation and nuclear terrorism. It should therefore be a high priority for the United States to help ensure that Chinese facilities have resilient MPC&A systems, and the best way to do so would be to re-start the U.S.-China lab-to-lab (CLL) program or to create new programs to strengthen or replace the CLL.

Unfortunately, given the worsening of relations between the United States and China, this will probably not be an option, at least for some time. The United States might therefore consider initiating other lab-to-lab collaborations that deal with less sensitive issues. While these programs will inevitably progress slowly, they can help increase transparency and mutual understanding between the two counties. It is only from such a position of trust that the United States could hope to encourage China to improve the MPC&A for its nuclear facilities.

**Pursue stronger, more consistent nonproliferation policies in India and Pakistan**

There are great challenges, but also great opportunities for U.S. policies in South Asia. India and Pakistan are currently at critical crossroads in their nuclear programs. Both countries have demonstrated their nuclear weapons capabilities, but neither has yet moved down the path toward weaponization and deployment. If the United States and the international community take advantage of this window of opportunity, they could stop the movement toward

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86 This is probably why the United States has refused to give China information about U.S. PALs.
weaponization and deployment before it is too late. Although a number of analysts have argued that nuclear weapons in South Asia are inevitable and the proper response should be to encourage India and Pakistan to improve crisis stability by helping establish confidence-building measures and by helping them develop command-and-control systems, this would not be the not the best approach. As we have seen, such measures would be unlikely to reduce the dangers of inadvertent or intentional nuclear war. Instead, the United States and the international community should focus their efforts on preventing India and Pakistan from weaponization and deployment as an intermediate step toward eventual denuclearization.

Such an undertaking will obviously be very difficult and will require able diplomacy, as well as a successful strategy of incentives and sanctions. These measures have so far been lacking from U.S. policy in South Asia. In the past, U.S. policies toward India and Pakistan suffered from inconsistency and a haphazard application of incentives and sanctions.87 During the Cold War, U.S. policymaking was guided by Cold War imperatives. As a result, the United States did not exert adequate nonproliferation pressures on either India or Pakistan because they were viewed as balances to China and the Soviet Union, respectively. The United States was also hesitant to apply sanctions on India because it was afraid of forcing India to turn to the Soviets for assistance. The lack of a consistent U.S. and international nonproliferation policy in South Asia encouraged both India and Pakistan to continue their nuclear weapons programs.88

Even after end of the Cold War, the United States still did not pursue a consistent nonproliferation policy in South Asia. During the 1990s, the United States retained its goals of rollback and the elimination of nuclear weapons in South Asia, but nuclear restraint became the dominant emphasis in U.S. nonproliferation policy. Even after the 1998 tests, the Clinton Administration took a similarly inconsistent stance on the role of sanctions. Although sanctions were initially put in place after the tests, the majority of these sanctions were removed after only two months. Instead, U.S. policy focused primarily on “engagement.” These changing policies again were correctly interpreted by India and Pakistan as a lack of U.S. resolve on nonproliferation issues.89

87 For a discussion of the inconsistent U.S. policies toward India and Pakistan, see Ahmed and Cortright, South Asia at the Nuclear Crossroads, pp. 4-18.
88 Ibid., pp. 9-14.
89 Ibid., pp. 15-18.
The United States should learn from the lessons of the past and take a consistent stand against proliferation in South Asia. The United States should take a stronger stand against the deployment of nuclear weapons and encourage both countries to refrain from weaponization. It should also encourage both countries to sign and ratify the Comprehensive Test Ban Treaty (CTBT). New U.S. policies should employ a consistent "carrots and sticks" approach, which would include both incentives and renewed sanctions.90

In the Indian case, where the nuclear scientific community has aggressively promoted nuclear weapons development, current U.S. sanctions on scientific collaboration should stay in place until there is evidence of tangible progress toward nonproliferation. The United States should also continue to retain sanctions on transfers of dual-use technologies that might help India’s nuclear program. The effectiveness of these sanctions is demonstrated by the repeated Indian calls for the end of these sanctions. In addition, because the Indian economy continues to open to international markets, it is increasingly vulnerable to external pressure. The United States should therefore make it clear that it is prepared to impose unilateral and international sanctions if India decides to deploy its nuclear weapons.91

At the same time, the United States should offer substantial economic and diplomatic incentives if India agrees to reign in its nuclear capabilities. For example, the United States could use its leverage within the international financial institutions to support larger loans and grants to India, incrementally instituted and conditional on verifiable nonproliferation benchmarks, such as signing and ratifying the CTBT. Furthermore, India could be offered permanent membership in the United Nations Security Council if it signs the NPT as a non-nuclear weapons state.92

In the Pakistani case, given the importance of U.S. arms sales and supplies to Pakistan’s military-dominated nuclear establishment, the United States should retain its military sanctions and encourage other influential actors to follow its example. Military concessions to Pakistan should be made contingent on demonstrated progress toward nonproliferation. In addition, because it has a slow rate of economic growth, Pakistan is a suitable candidate for external

90 The following discussion of what a successful "carrots and sticks" approach would be is based on Ahmed and Cortright, South Asia at the Nuclear Crossroads.
91 Ibid., pp. 26–27.
92 Ibid., p. 32. If India were offered membership on the UN Security Council, Germany and Japan should probably be simultaneously offered membership to avoid any perception that India’s membership was a reward for nuclear testing.
inducements and pressure to cap its nuclear weapons program. Since its ailing economy remains heavily dependent on external grants and loans, substantial unilateral and multilateral soft grants and loans, enhanced U.S. economic aid, and preferential access to U.S. markets in return for nonproliferation progress will influence Pakistan’s assessment of the benefits of nuclear weapons.93 The potential success of such an approach is demonstrated by Pakistan’s recent consideration of signing the CTBT in return for Japanese loans.94 If the United States were to follow Japan’s lead and help garner support among other wealthy nations, such a policy would have a much greater chance of success.95

Since the 1998 nuclear tests, sections of the Pakistani political elite have reportedly questioned the wisdom of acquiring nuclear weapons and have expressed concerns about the potential economic burden of an overt nuclear weapons program.96 This debate, which received a serious blow after the 1999 military coup, should be vigorously encouraged by the United States through targeted support for reform-oriented civilian constituencies. Targeted financial and military sanctions should be maintained to exert pressure for the restoration of the democratic process. A carrot-and-sticks approach that combines conditional financial and political incentives with multilateral military sanctions could influence Pakistani public opinion and pressure Pakistani officials incrementally to adopt nonproliferation norms.97

Part III: The Perils of Abstract Theorizing

Until now, the proliferation debate has largely taken place on an abstract, theoretical level. No doubt this orientation partly reflects perfectly legitimate scholarly concerns: in order to improve our understanding of international affairs, we of course need to establish theories to explain and predict state action. Participants in the proliferation debate have gone astray,

93 Ibid., p. 27.
95 This policy option would obviously run some risks of collapsing Pakistan’s economy, an event that would have serious consequences for the Pakistani people as well as Pakistan’s nuclear controls. In addition, it is unlikely that Pakistan would sign the CTBT if India did not.
97 Ahmed and Cortright, South Asia at the Nuclear Crossroads, p. 27.
however, in placing theorizing at the beginning, rather than at the end of their thinking. Instead of building theories on solid evidence gathered from rigorous empirical studies, they have too often predicted future state actions only on the basis of preexisting theories. From a scholarly point of view, one of the most important lessons from the present study is that we cannot afford anything other than a relentlessly empirical foundation for—and check on—theory.

While abstract theorizing can be found on both sides of the debate, it is especially common among the optimists. Rather than asking how NWSs actually do act, optimists have begun with theories of how states should act—that is, in accordance with supposedly “realist” rational-actor models—and predicted the actions of states on that basis. One need only recall Waltz’s confident statement, “We do not have to wonder whether they [NWSs] will take good care of their weapons. They have every incentive to do so.” On the contrary, the proper approach to theory would begin with wonder about whether states do, in fact, always act with such rational incentives in mind. As the present study has demonstrated, there is little empirical support for such an optimistic position where nuclear proliferation is concerned. While realist theories may be useful for explaining certain types of state actions, they are inappropriate models for predicting specific policies and actions that NWSs will take.

Having oversimplified the causes and motivations of state action, the optimists make highly inappropriate policy recommendations regarding nuclear proliferation. Indeed, those recommendations go beyond what the optimists’ own theories could possibly support. In a context other than the proliferation debate, Waltz argues that his theories cannot predict specific policies or particular actions by individual states; instead, he maintains, they can predict only general trends. But, as Jeffrey Knopf has pointed out, when one is advocating a further proliferation of nuclear weapons, predicting general trends is not enough: one must be certain that one’s theories are correct all of the time. It is likely that a certain awareness of the special dangers attending nuclear weapons policy leads Waltz to misapply his own realist theory and predict that NWSs will act rationally without exception. But that awareness must be replaced by

fully conscious practical reasoning. Empirically grounded theories, combined with the prudence of the policymaker, would lead to policy recommendations that are more sound.

Absent a nuclear exchange, or a series of nuclear exchanges, we will lack conclusive proof that a further spread of nuclear weapons will lead to nuclear catastrophes. May such a proof never be forthcoming. In the meantime, however, I hope this study will contribute to more nuanced and accurate theorizing about state action—theories acknowledging that while states sometimes act rationally, they often fail to do so when constrained by certain political, bureaucratic, economic, and other factors. I also hope this study will also contribute to better-informed policymaking on nuclear issues. Although continued study of the historical record and future developments will surely provide additional relevant information, it is already fairly clear that U.S. and global interests lie in preventing a further spread of nuclear weapons and reducing nuclear dangers among current NWSs as much as possible. If the United States takes the lead in these areas, we will make progress toward making the world a safer place.
Appendix A: Current IAEA-Related Standards for MPC&A

One of the major issues this dissertation examines is the adequacy of the MPC&A programs in the NWSs. It is therefore critical that we establish a standard by which we can judge whether or not a given MPC&A program is “adequate.” What, then, would an “adequate” MPC&A system look like? This is not an easy question to answer. Before we can answer this question, however, we need to examine what objectives an MPC&A program should try to achieve.

An effective MPC&A system serves up to four different objectives:

1. Prevent the theft of nuclear materials
2. Prevent the sabotage of a nuclear facility (or a nuclear transport vehicle).
3. Detect the theft of nuclear materials once it has occurred.
4. Detect the diversion of nuclear materials by a given state from its peaceful nuclear program to an opaque nuclear weapons program.

In order to achieve these objectives, MPC&A systems are generally divided into two distinct, thought interrelated systems: Physical Protection and Material Control and Accounting (MC&A). A physical protection system is designed to prevent the theft of nuclear materials or sabotage of nuclear materials or facilities.1 These objectives are achieved in two ways: by deterring threats or by defeating them should groups or individuals attempt to steal nuclear materials or sabotage nuclear facilities.2 This deterrence is achieved by implementing a physical protection system that is perceived to be too difficult to overcome. And, of course, if anyone does attempt to steal materials or to sabotage a facility, the physical protection system must also be able to stop the attempt. An effective physical protection system will use barriers, surveillance systems, alarms, and guards to achieve these goals.

Nuclear material control and accounting (MC&A) systems, on the other hand, are used to detect a theft or diversion of nuclear materials once it has occurred. It is only possible to discover whether some materials have disappeared if one knows the exact location and amounts of nuclear materials in a given facility. The material must be effectively “controlled” by means of portal monitors to detect any materials passing from nuclear material storage sites, secure containers for nuclear material, tamper-resistant seals, and identification codes that make it

\[1\] Guidance and Considerations for Implementation of INFCIRC/225/Rev.3, par. 401.
\[2\] Ibid. par. 402
possible to verify easily the location and storage condition of nuclear material. In addition, there must be effective “accounting” systems in place to provide “a regularly updated, measured inventory of nuclear weapons usable material, based on routine measurements of material arriving, leaving, lost to waste and remaining within the facility.”

The MC&A systems required by the International Atomic Energy Agency (IAEA) are used to detect whether a NNWS has diverted nuclear materials from its peaceful nuclear programs into a nuclear weapons program. The MC&A systems in the NWSs, on the other hand, are primarily intended to detect a theft of nuclear materials for use by (or sale to) either a terrorist group, or a country that wants to build a nuclear weapons. While a physical protection system might be very useful in opposing an attempt by an outsider to steal fissile materials, MC&A is a means of detecting such attempts by insiders. While MC&A is mainly useful in detecting a theft after it has occurred, it can also serve as a deterrence against the insider threat, because it will often be possible to trace who the insider was once it has been discovered that nuclear materials have disappeared.

Now that we have seen what an MPC&A program is supposed to do, we can examine what specific requirements are necessary in order to achieve these goals. This is an issue that International Atomic Energy Agency has spent a great deal of time attempting to answer. Since its inception, the IAEA has been responsible for facilitating the use of nuclear energy for peaceful purposes and implementing a system of audits and on-site inspections, collectively known as “safeguards,” to verify that nuclear facilities nuclear facilities and materials are not being diverted for nuclear explosive purposes. As part of its responsibilities, the IAEA has helped create recommendations and standards for MPC&A systems. Although the IAEA regulations apply only to peaceful nuclear materials, they also give us a good idea of what a complete MPC&A system for nuclear materials would look like. They therefore give us a standard by which we can judge the adequacy of the MPC&A in the NWSs.

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4 Ellis and Perry, “Nunn-Lugar’s Unfinished Agenda,” p. 16.
5 In the context of the IAEA, “safeguards” are the collective system of audits and on-site inspections intended to verify that the use of nuclear energy is exclusively for peaceful purposes. See Rodney Jones, Mark McDonough, with Toby Dalton and Gregory Koblentz, Tracking Nuclear Proliferation: A Guide in Maps and Charts, 1998 (Washington, DC: Carnegie Endowment for International Peace, 1998), p. 16.
It is necessary to explain the general background for IAEA regulations. In Parts I and II below, I therefore briefly describe the IAEA-related treaties that establish the laws and norms for MC&A, then discuss the specific requirements for MC&A that arise from these treaties. I follow the same procedure in Parts III and IV below for physical protection standards.

I: IAEA Treaties that Help Establish Standards for MC&A

Limited-scope Safeguards (covered under INFCIRC/66)

The very first IAEA safeguards system was outlined in INFCIRC/26. The document required inspections of the reactors, but “except in the case of an incident requiring a ‘special inspection,’ at least one week’s notice was to be given of each inspection; the notice must include the name(s) of the inspector(s), the place and time of arrival in the State concerned and the items to be inspected.” Although significant for being the first safeguard system, INFCIRC/26 left much to be desired. Its first and most obvious shortcoming was that only applied to reactors less than 100 MW (th). In addition, because of the political battles during its negotiation, the final document was “one of the most convoluted pieces of verbal expression in history.” In February 1963, the Board of Governors of the IAEA unanimously agreed that INFCIRC/22 needed to be clarified, and safeguards extended to cover reactors of any size.

It took until June 1965 to reach unanimous agreement in favor of INFCIRC/66, which applied safeguards to all sizes of nuclear reactors. It was later revised, so that safeguards would be applied to reprocessing plants (in INFCIRC/66/Rev.1 in 1966) and fuel fabrication plants (in INFCIRC/66/Rev.2 in 1968). INFCIRC/66 established what came to be called “limited-scope” safeguards. These safeguards are placed on individual plants, shipments of nuclear fuel, or supply agreements between importers and exporters of nuclear fuel or technology.

INFCIRC/66 does not explicitly require a system for accounting and control (MC&A), but it does require a “system of records” and a “system of reports,” which together would

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7 Quoted in Fischer, History of the International Atomic Energy Agency, p. 249.
8 Ibid.
essentially require an MC&A program.\textsuperscript{10} It says nothing about any standards for physical protection for nuclear facilities.

Under INFCIRC/66, it is possible for a nation to have both safeguarded and unsafeguarded nuclear facilities. Limited-scope safeguards are currently still applied to the states that have not signed the Treaty on the Nonproliferation of Nuclear Weapons (NPT): Cuba, India, Israel, and Pakistan.

\textit{Treaty on the Nonproliferation of Nuclear Weapons (NPT)}

The NPT is the cornerstone for current international efforts in nuclear nonproliferation. It was opened for signature in 1968, and entered into force in 1970. As of September 1998, every country in the world had signed the NPT except Cuba, India, Israel, and Pakistan.\textsuperscript{11} The NPT essentially says that the nuclear weapons states (NWSs) will help non-nuclear weapons states (NNWSs) with their peaceful nuclear programs as long as the NNWSs promise not to use these technologies as part of an opaque nuclear program.\textsuperscript{12} In addition, Article VI of the NPT says that each party to the treaty will undertake to work toward nuclear disarmament.

Article I of the NPT forbids any nuclear weapons state (NWS) party to the treaty from transferring “to any recipient whatsoever nuclear weapons or other nuclear explosive devices or control over such weapons or explosive devices directly or indirectly; and not in any way to otherwise acquire nuclear weapons or other nuclear explosive devices, or control over such weapons or explosive devices.” Thus, the NPT also implies that the NWSs should have strict fissile material protection, control, and accounting (MPC&A), since inadequate controls could increase risks of thefts of fissile materials, which could ultimately allow aspiring nuclear powers to develop nuclear weapons. Of course, MPC&A in the NWSs is not the most direct purpose of the NPT. It focuses much more on intentional transfers of nuclear weapons technologies from the NWSs to the NNWSs and on the illicit diversion of nuclear materials and technologies from peaceful nuclear programs in the NNWSs.

\textsuperscript{10} INFCIRC/66, Articles 33–40.

\textsuperscript{11} Algeria and Chile have signed the NPT, but their facilities are not yet completely under full-scope safeguards (See Nuclear Nonproliferation and Safety: Challenges Facing the International Atomic Energy Agency, United States General Accounting Office, September 1993, GAO/NSIAD/RCED-93-284). Unlike India, Israel, and Pakistan, Cuba is not believed to have an active nuclear weapons program.

\textsuperscript{12} For a discussion of “opaque” nuclear weapons programs, see Avner Cohen and Benjamin Frankel, “Opaque Nuclear Proliferation,” \textit{Journal of Strategic Studies}, vol. 13, no.3 (September 1990), pp. 14–44.
Article II of the NPT says that each NNWS Party to the Treaty agrees not to receive or develop any nuclear weapons technologies, either directly or indirectly. In order to verify this commitment, Article III of the NPT says that the NNWSs should undertake to accept IAEA safeguards "for the exclusive purpose of verification of the fulfillment of its obligations assumed under this treaty." The NPT therefore provides the basis for full-scope international safeguards, but it does not specify in detail how the safeguards are to be implemented in each NNWS or the techniques and methods to use. The specific details for full scope safeguards were laid out in INFCIRC/153.

**Full-Scope Safeguards (covered under INFCIRC/153)**

INFCIRC/153 establishes a system of safeguards to will help verify that NNWSs fulfill the commitments they undertook in the NPT not to divert nuclear materials into opaque nuclear weapons programs. As such, it places no specific requirements on the NWSs. This fact, however, was the cause of intense debate for several years after the NPT entered into force. Many of the NNWSs were concerned that the full scope safeguards would give the NWSs a competitive advantage in their peaceful nuclear programs. In order to appease these concerns, President Johnson offered to apply safeguards to all nuclear activities in the U.S. other than those with direct national security significance. The offer took affect in 1980. Since then, the United Kingdom, France, and Russia have made similar offers. But there are still no safeguards on the nuclear weapons programs in the NWSs.

Part I of INFCIRC/153 outlines the general principles governing the rights and obligations of the parties to the NPT. In order to verify that no nuclear material has been diverted into nuclear weapons programs, it is critical that the IAEA know exactly how much nuclear material a state has at each stage of its nuclear cycle. INFCIRC/153 therefore makes specific requirements for nuclear material control and accounting (MC&A) in the NNWSs:

The Agreement should provide that the State shall establish and maintain a system of accounting for and control of all nuclear material subject to safeguards under the Agreement, and that such safeguards shall be applied in such a manner as to enable the Agency to verify, in ascertaining that there has been no diversion of nuclear material from peaceful uses to nuclear weapons or other nuclear explosive devices, findings of the State’s system.

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13 For details in the commitments that the NWS undertook in these voluntary offers, see the IAEA web site: <http://www.iaea.or.at/worldatom/program/safeguards/97tables/p83safebs.html#iii> and Fischer, *History of the International Atomic Energy Agency*, pp. 271–272.

14 INFCIRC/153, section 1.7.
Part II of INFCIRC/153 explains the requirements for the MC&A program in much greater detail. I will discuss these specific requirements in my own Part II below.

INFCIRC/153 also makes provisions for the IAEA to conduct inspections of declared nuclear facilities in the NNWSs. The agency must conduct an initial (ad hoc) inspection to determine the amount of nuclear materials that a given state possesses in its declared nuclear facilities. After that, the Agency can make routine inspections to verify that that State’s “reports are consistent with its records” and to verify “the location, identity, quantity and composition of all nuclear material subject to safeguards under the Agreement.”15 The Agency can also conduct “special inspections” if it “considers that information made available by the State, including explanations from the State and information obtained from routine inspections, is not adequate for the Agency to fulfil its responsibilities under the Agreement.”16 In both these cases, the IAEA must give the given state prior notification that it will conduct the inspections.17

**Strengthened Safeguards System (Programme 93+2) and “Integrated Safeguards”**

Although the full-scope safeguard system has done a fairly good job at verifying the safeguards agreements undertaken in the NPT, it has some serious shortcomings. Its greatest shortcoming is that the IAEA is only given the authority to inspect the inventories of declared nuclear facilities to ensure that nuclear material had not been diverted to weapons programs. Full-scope safeguards simply do not apply to any nuclear materials produced or stored at undeclared nuclear facilities. The Persian Gulf War revealed the weakness of the full-scope safeguard system. It came to light the Iraq had an extensive opaque nuclear weapons program and had come very close to making a nuclear weapon. It was later discovered that North Korea had also engaged in an opaque nuclear weapons program. Iraq and North Korea were violating the NPT, since they had promised not to develop nuclear weapons when they signed the treaty. But the IAEA was unable to detect these violations, since they occurred at undeclared nuclear facilities. As a result of these evident weaknesses in the full-scope safeguards system, the IAEA undertook a study to determine ways to strengthen the safeguards system. This study was known as the 93+2 Program, and gave rise to a two-part Strengthened Safeguards System.

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15 INFCIRC/153, par. 72.
16 Ibid., par. 73.
17 For routine inspections, the inspections must occur at least 24 hours after notification; in special inspections, the inspections should take place "as soon as possible" after notification.
In 1995, the IAEA’s Board of Governors approved Part I of the Strengthened Safeguards System. Part I provides for the following measures:

- Non-nuclear weapons states are now required to provide IAEA with additional information about nuclear activities undertaken prior to entry into force of their safeguards agreements.
- IAEA’s inspectors are now allowed to perform environmental sampling at facilities and locations where they currently have access.
- IAEA is increasing its access to all declared nuclear and nuclear-related locations and will employ the use of unannounced inspections.
- IAEA is testing new safeguards measurement and surveillance systems that can operate unattended and can transmit safeguards data remotely.
- IAEA is increasing its cooperation with state and regional systems of accounting and control, including those in the European Union, performed by the European Atomic Energy Community (EURATOM) and those between Brazil and Argentina.\(^\text{18}\)

Part II of the Strengthened Safeguards System was passed by the Board of Governors in May 1997, and was codified in INFCIRC/540, the *Model Protocol Additional to the Agreement(s) between State(s) and the International Atomic Energy Agency for the Application of Safeguards*, or the Model Additional Protocol. The Model Additional Protocol measures include the following:

- IAEA will gather information about all aspects of a state’s nuclear fuel cycle, including information about research and development on the nuclear fuel cycle, the manufacture and export of sensitive and other key nuclear-related equipment, and all buildings on a nuclear site.
- IAEA inspectors will be provided access to all aspects of a state’s nuclear fuel cycle including; facilities at which nuclear fuel-cycle research and development is carried out; manufacturing and import locations and all buildings on a nuclear site, including undeclared or suspect sites. This is to provide, among other things, a deterrent to the co-location of clandestine and peaceful activities. IAEA may exercise this right through short notice inspections on sites where nuclear material is located and at other locations. This access will include the right to take environmental samples.
- IAEA inspectors will be provided access to conduct “wide-area” environmental monitoring, that is, collecting environmental samples beyond declared locations when deemed necessary.
- States will improve their administrative arrangements for designating inspectors and issuing multiple-entry visas to facilitate unannounced/short notice inspections and permit access to modern means of communication.\(^\text{19}\)


\(^{19}\) Ibid., pp. 7-8. This document not only provides an excellent summary of the new measures included in the Strengthened Safeguards system, but it also assesses the feasibility of these measures, given current IAEA funding levels.
As of May 14, 2001, the Additional Protocols had been signed by fifty-five states and had entered into force in nineteen states.\textsuperscript{20}

Most of the IAEA's current and future work on the Strengthening Safeguards System continues to be that of integrating traditional nuclear material verification activities with new strengthening measures.\textsuperscript{21} This endeavor is now called Integrated Safeguards. Many of the details on Integrated Safeguards have yet to be determined, but the new IAEA authorities could allow for a redefinition of traditional safeguards activities. In particular, if the IAEA were able to obtain a positive conclusion on the absence of undeclared nuclear material activities in a given state as a whole, particularly on activities related to enrichment and reprocessing, it might be able to reduce current levels of traditional safeguards verification efforts on undeclared nuclear materials.\textsuperscript{22}

II. Specific MC&A Standards set by INFCIRC/153

To a certain degree, the IAEA safeguards are intended to serve a different purpose than the MC&A programs in the weapons states would. The goal of the IAEA safeguards is to detect whether any NNWS is diverting nuclear materials from a peaceful nuclear program into an opaque nuclear weapons program. This is simply not a concern for the NWSs. In the NWSs, we are concerned with the possibility of theft of nuclear materials, especially by insiders. But the only way to detect whether anyone has illegally obtained nuclear materials from the NWSs is if the NWSs have adequate MC&A systems. Thus, the standards for MC&A established by INFCIRC/153 will be an excellent measure by which we can judge the adequacy of the MC&A in the NWSs.

INFCIRC/153 explicitly requires the State signatories to establish a state system of accounting and control (SSAC) for nuclear materials.\textsuperscript{23} The first step in setting up this system is

\textsuperscript{20} For a list of these countries, see IAEA web site: <http://www.iaea.or.at/worldatom/inforesource/newsbriefs/newsrv13n4.html#A6.1>
\textsuperscript{22} Ibid., p. 8.
\textsuperscript{23} SSAC is sometimes distinguished from MC&A. When a distinction is made, the MC&A refers to the accounting and control over nuclear materials at a specific nuclear facility, while SSAC refers to the overall state coordination of the MC&A programs. See Annette Schaper, "The Case for Universal Full-Scope Safeguards on Nuclear
to identify "material balance areas," or key places where the amounts of nuclear material entering and exiting the facility can be one can be measured. In addition, INFCIRC/153 requires the following provisions:

(a) A measurement system for the determination of the quantities of nuclear material received, produced, shipped, lost or otherwise removed from inventory, and the quantities on inventory;
(b) The evaluation of precision and accuracy of measurements and the estimation of measurement uncertainty;
(c) Procedures for identifying, reviewing and evaluating differences in shipper/receiver measurements;
(d) Procedures for taking a physical inventory;
(e) Procedures for the evaluation of accumulations of unmeasured inventory and unmeasured losses;
(f) A system of records and reports showing, for each material balance area, the inventory of nuclear material and the changes in that inventory including receipts into and transfers out of the material balance area;
(g) Provisions to ensure that the accounting procedures and arrangements are being operated correctly; and
(h) Procedures for the provisions of reports to the Agency.

INFCIRC/153 requires that State signatories be able to calculate "material unaccounted for" (MUF) with the following formula:

\[ MUF = BI + A - EI - R - KL \]

In order to ensure an accurate MUF, the state should establish a specific records system, which will consist of accounting records of all nuclear material subject to safeguards, and operating records for facilities containing such nuclear material.

The accounting records should consist of:

- All inventory changes, so as to permit a determination of the book inventory at any time;
- All measurement results that are used for determination of the physical inventory;
- All adjustments and corrections that have been made in respect of inventory changes, book inventories and physical inventories;
- Any differences between shipper and receiver reports;
- For all of these inventory changes and physical inventories, the records should show the material identification, batch data and source data for each given batch of nuclear material.

Material," Nonproliferation Review, vol. 5, no. 2 (Winter 1998), p. 74. I do not make a similar distinction, however, because these terms are in fact often used synonymously.
The *operating records* should consist of:

- Those operating data which are used to establish changes in the quantities and composition of nuclear material;
- The data obtained from the calibration of tanks and instruments and from sampling and analyses, the procedures to control the quality of measurements and the derived estimates of random and systematic error;
- A description of the sequence of the actions taken in preparing for, and in taking, a physical inventory in order to ensure that it is correct and complete; and
- A description of the actions taken in order to ascertain the cause and magnitude of any accidental or unmeasured loss that might occur.

If the state makes detailed records in every one of these areas, it would have a very high likelihood of detecting whether any nuclear materials has been diverted or stolen.24

**III: IAEA Documents and Treaties that Help Establish Standards for Physical Protection of Fissile Materials**

While INFCIRC/153 establishes standards for MC&A (albeit only in the NNWSs), it says nothing about physical protection.25 There are two major IAEA documents that establish the standards for the physical protection: INFCIRC/274, rev.1, which was the result of the 1979 Convention on the Physical Protection of Fissile Materials (PPC); and INFCIRC/225, rev.4, *The Physical Protection of Nuclear Material and Nuclear Facilities.*26 The PPC entered into force in 1987 and 60 states are now members of the treaty.27 Although the PPC establishes some standards for physical protection, it only covers the transfer of materials for peaceful purposes across international borders, and it has no provision for verification or enforcement.

INFCIRC/225, rev.4 is the document where IAEA systematically lays out its recommendations for physical protection during use, storage, and transportation. INFCIRC/225

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24 INFCIRC/153 does not describe any specific requirements for material control systems. While specific agreements between the IAEA and individual countries reportedly do contain provisions for material control, these agreements generally confidential.


26 Several additional documents help establish physical protection norms, although they do not explicitly create any physical protection regulations. For example, the Nuclear Safety Convention (which convened in 1994 and was codified in INFCIRC/449) establishes safety standards for "land-based civil nuclear power plant under [IAEA] jurisdiction including such storage, handling and treatment facilities for radioactive materials that are on the same site and are directly related to the operation of the nuclear power plant." This does not apply to weapons facilities, however.

was originally published in 1975, but it was revised several times afterwards.28 The latest version, INFCIRC/225/Rev.4, was published in 1998. This is the document that I will use as a standard for assessing the adequacy of the physical protection systems in the NWSs.29

Although INFCIRC/225 document has never actually been implemented, a number of IAEA documents refer to it. For example, the Nuclear Suppliers Group (INFCIRC/254, rev2) states that all items listed in their “trigger group” should be placed under physical protection that takes into account all international standards and refers to INFCIRC/225 as a “useful basis for guiding recipient States in designing a system of physical protection measures and procedures.”30

Another important IAEA document that refers to INFCIRC/225 is the Guidelines for the Management of Plutonium (GMP). This document, codified in INFCIRC/549, was opened for signature in March 1998. It presents rigorous requirements for the management and disposition for excess plutonium used for peaceful purposes. It establishes MC&A standards similar to INFCIRC/153, and says that states should implement physical protection regulations “taking into account” INFCIRC/225, rev.3.31

IV. Specific Physical Protection Recommendations in INFCIRC/225

While INFCIRC/153 establishes standards for control and accounting (albeit only in the NNWSs), it says nothing about physical protection. The standards for the physical protection of SNM are established by INFCIRC/225. INFCIRC/225 is intended to “establish conditions which would minimize the possibilities for unauthorized removal of nuclear material or for sabotage.”32 To achieve this end, it provides “a set of recommendations on requirements for the physical protection of nuclear material in use, transit, and storage and of nuclear facilities.”33

29 Although this document is probably the best standard to use, there have been other, more rigorous, recommendations for physical protection. For example, the National Academy of Sciences recommends a separate standard for facilities that store weapons-useable plutonium. See the NAS publication, Management and Disposition of Excess Weapons Plutonium, <http://www.nap.edu/readingroom/reader.cgi?auth=free&label=ul_book.0309050421>.
30 INFCIRC/254/rev.2, Annex C.
31 For a more thorough discussion of international agreements that refer to INFCIRC/225, see Jenkins, “Establishing International Standards for Physical Protection of Nuclear Material,” pp. 102–103.
32 Sabotage is defined as “Any deliberate act directed against a nuclear facility or nuclear material in use, storage or transport which could directly or indirectly endanger the health and safety of personnel, the public and the environment by exposure to radiation or release of radioactive substances” (INFCIRC/225/rev.4, section 2.12).
33 INFCIRC/225, rev.4, section 2.2.a.
INFCIRC/225 establishes a set of guidelines for the categorization of fissile materials and what physical protection measures should correspond to the different classification levels. Materials are divided into three categories, depending on the type of material, the physical and chemical form, the degree of dilution, radiation level, and the quantity of the material present. The three categories are outlined in Table A.1:

<table>
<thead>
<tr>
<th>Material</th>
<th>Form</th>
<th>Category I</th>
<th>Category II</th>
<th>Category III</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Plutonium</td>
<td>Unirradiated</td>
<td>2 kg or more</td>
<td>Less than 2 kg but more than 500 g</td>
<td>500 g or less but more than 15 g</td>
</tr>
<tr>
<td>2. Uranium-235</td>
<td>Unirradiated:</td>
<td>5 kg or more</td>
<td>Less than 5 kg but more than 1 kg</td>
<td>1 kg or less but more than 15 g</td>
</tr>
<tr>
<td></td>
<td>-uranium enriched to</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20% U-235 or more</td>
<td></td>
<td>10 kg or more</td>
<td>Less than 10 kg but more than 1 kg</td>
</tr>
<tr>
<td></td>
<td>-uranium enriched to</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10% U-235 but less than 20% U-235</td>
<td></td>
<td></td>
<td>10 kg or more</td>
</tr>
<tr>
<td></td>
<td>-uranium enriched</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>above natural, but less than 10% U-235</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Uranium-233</td>
<td>Unirradiated</td>
<td>2 kg or more</td>
<td>Less than 2 kg but more than 500 g</td>
<td>500 g or less but more than 25 g</td>
</tr>
<tr>
<td>4. Irradiated Fuel</td>
<td></td>
<td>Depleted or natural uranium, thorium or low-enriched fuel (less than 10% fissile content)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

After INFCIRC/225 establishes the three categories for fissile material, it recommends the corresponding guidelines for physical protection. The physical protection guidelines “should take into account the category of nuclear material, its location (use, transit, storage) and the particular circumstances prevailing either in the State or along the transportation route.”34 The physical protection measures that correspond to each category for fissile materials in use storage are summarized in Section A below and those measures for materials in transit are the summarized in Section B.

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34 INFCIRC/225/Rev.4, section 4.2.5.1.
A. Physical Protection Recommendations for Special Nuclear Materials in Use and Storage

Requirements for Category I Materials in Use and Storage

During use and storage, Category I materials should be contained in at least two complete, reliable areas, an outer "protected area" and a more secure "inner area." I will discuss the physical protection recommendations for each of these areas in turn.\(^{35}\)

*Inner area(s)*
- All Category I materials should be used or stored within the inner area or inner areas.
- Access to the inner area should be restricted to employees whose duties require access to this area. These employees should carry badges demonstrating authorization.
- There should be a limited number of entrances to the inner area. All emergency exits should be fitted with alarms.
- Fissile materials should be stored in a vault in the inner area. The vault should be protected by alarms and adequate locks, and the issue of keys or key-cards should be closely controlled.
- Whenever persons are present in inner areas, those areas should be under constant surveillance. The surveillance can be effected by mutual observation between two or more co-workers (e.g. a two-person rule).
- Material should be protected by guards at all times. An external and internal patrol should be provided.

*Protected area(s)*
- The protected area should be under constant surveillance (by a guard or by electronic means). The perimeter of the protected area should normally consist of a physical barrier (a fence, wall or a similar impediment approved by a security survey) in addition to and outside the walls of the building itself.
- Access to the protected area should be restricted to those whose duties require access to this area.
- Entry of private motor vehicles into the protected area should be minimized and limited to authorized parking areas. Private motor vehicles should be prohibited from access to inner areas.

Requirements for Category II Material in Use and Storage:

- Category II material should be used or stored within a protected area or protected areas. The protected area should be under constant surveillance (by a guard or by electronic means). The perimeter of the protected area should normally consist of a physical barrier (a fence or wall or a similar impediment approved by a security survey) in addition to and outside the walls of the building.

\(^{35}\) The requirements outlined in INFCIRC/225 are more extensive than I can describe here. I try to summarize as many of the major points as possible.
- All persons entering the protected area should be issued either with special passes or with badges, appropriately registered, and access to the protected area should be kept to the minimum necessary. A record should be kept of all persons having access to or possession of keys or key-cards concerned with the containment or storage of nuclear material.

- Vehicles and all large objects entering the protected area should checked to ensure that no unauthorized persons or articles of sabotage are introduced. Entry of private motor vehicles into the protected area should be minimized and limited to authorized parking areas.

Requirements for Category III Material in Use and Storage:
- Category III material should be used or stored within an area to which access is controlled.
- Provision should be made for detecting unauthorized intrusion and for appropriate action by guards or off-site response forces to attempted intrusion.

B. Physical Protection Recommendations for Nuclear Materials in Transit

Since nuclear material is probably the most vulnerable during transit, it is extremely important to have specific regulations governing its protection during these times. But international standards for the physical protection of nuclear materials during these times have been very weak. Before the publication of INFCIRC/225, the only regulations governing the transport of nuclear materials were those established by the Convention on the Physical Protection of Fissile Materials (PPC). As we have seen, however, the PPC only applies to the transport of fissile materials used for peaceful purposes, and only governs the transport of fissile materials across international borders. It says nothing about the transport of weapons-useable materials, or nuclear materials within a given state. The standards established by INFCIRC/225 over the transport of fissile materials are therefore extremely important, since they apply to the transport of all types of nuclear material, and also establish standards for the transport of materials within states.

General techniques for the protection of nuclear material in transit
- Minimizing the total time during which the nuclear material is in transit.
- Protecting nuclear material in temporary storage in a manner consistent with the category of that material.
- Avoiding the use of regular movement schedules.
- Requiring predetermination of trustworthiness of all individuals involved in transport of nuclear material.
- Limiting advance knowledge of transport information to the minimum number of persons necessary.
Requirements for Category I Material in Transit

- **Advance notification to receiver.** The shipper should give the receiver advance notice of the planned shipment specifying the mode of transport (road/rail/sea/air), the estimated time of arrival of the shipment and the exact point of hand-over if this is done before the ultimate destination.

- **Selection of transportation and routing.** In choosing the route, consideration should be given to the security of passage, in particular, arranging the route in such a way as to avoid areas of natural disasters or civil disorders. The mode of transport for any consignment should be such as to keep to a minimum the number of cargo transfers and the length of time the cargo remains in transit.

- **Provision of locks and seals.** Unless there are overriding safety considerations, the packages containing nuclear material should be carried in closed, locked vehicles, compartments or freight containers. Checks should be made before dispatch to confirm the integrity of the locks and seals on the package, vehicle, compartment or freight container.

- **Search of load vehicle.** There should be a detailed search of the load vehicle prior to loading and shipment, to ensure that sabotage devices have not been implanted or that sabotage has not been initiated.

- **Measures after shipment.** The receiver should check the integrity of the packages, locks, and seals and accept the shipment immediately upon arrival.

- **Communication.** Domestic physical protection measures should include provision of continuous two-way radio communication or frequent telephone communication between the vehicle and shipper/receiver/state designee.

- **Guards.** Guards should accompany each shipment to protect the material against hostile acts. States are encouraged to use armed guards to the extent that laws and regulations permit.

- **Agreements for international transit.** In contracts or agreements between shippers and receivers involving international transit of material, the point at which responsibility for physical protection is transferred from the shipper to the receiver should be clearly stated.

Requirements for Category II Material in Transit

- **Advance notification to receiver.** The shipper should give the receiver advance notice of the planned shipment specifying the mode of transport (road/rail/sea/air), the estimated time of arrival of the shipment and the exact point of hand-over if this is done before the ultimate destination.

- **Selection of transportation and routing.** In choosing the route, consideration should be given to the security of passage, in particular, arranging the route in such a way as to avoid areas of natural disasters or civil disorders. The mode of transport for any consignment should be such as to keep to a minimum the number of cargo transfers and the length of time the cargo remains in transit.

- **Provision of locks and seals.** Unless there are overriding safety considerations, the packages containing nuclear material should be carried in closed, locked vehicles, compartments or freight containers. Checks should be made before dispatch to confirm the integrity of the locks and seals on the package, vehicle, compartment or freight container.
• **Search of load vehicle.** There should be a detailed search of the load vehicle prior to loading and shipment, to ensure that sabotage devices have not been implanted or that sabotage has not been initiated.

• **Measures after shipment.** The receiver should check the integrity of the packages, locks, and seals and accept the shipment immediately upon arrival.

• **Communication.** Domestic physical protection measures should include provision of frequent communication between the vehicle and shipper/receiver/state designee.

• **Agreements for international transit.** In contracts or agreements between shippers and receivers involving international transit of material, the point at which responsibility for physical protection is transferred from the shipper to the receiver should be clearly stated.

**Requirements for Category III Material in Transit**

- **Advance notification to receiver.** The shipper should give the receiver advance notice of the planned shipment specifying the mode of transport (road/rail/sea/air), the estimated time of arrival of the shipment and the exact point of hand-over if this is done before the ultimate destination.

- **Provision of locks and seals.** Where practicable, locks and seals should be applied to vehicles or freight containers.

- **Search of load vehicle.** There should be a detailed search of the load vehicle prior to loading and shipment, to ensure that sabotage devices have not been implanted or that sabotage has not been initiated.