



Nuclear weapons

Primed and ready

BY BRUCE G. BLAIR

A Cold War mind-set still dominates the United States and Russia, aggravating the risk of nuclear theft—or accidental nuclear war.

AMERICAN AND RUSSIAN POLITICAL RHETORIC attaches the highest priority to imposing ironclad control over their nuclear arsenals. The two nations cooperate extensively and devote substantial resources to achieving this aim, particularly to preventing terrorists from stealing or buying Russian nuclear weapons or raw materials.

But both nations are shooting themselves in the foot by allowing hoary Cold War priorities to take precedence. The anachronistic mind-set of the Cold Warrior still dominates their nuclear establishments, their agendas, and their relationship in ways that deeply undermine

their efforts to contain “loose nukes.” They spend 25 times more money to preserve their Cold War nuclear deterrent postures than they spend on shoring up security against theft. Moreover, their deterrent operations not only undercut theft prevention, but also aggravate a wider range of nuclear dangers, including unauthorized, accidental, and mistaken launch.

Since the inception of the Cooperative Threat Reduction program (more commonly known as the Nunn-Lugar program) 15 years ago, the United States has invested roughly \$1 billion each year toward preventing the theft of Russian nuclear weapons and materials. The money goes toward improving security at hundreds of nuclear sites; deactivating nuclear warheads; destroying nuclear submarines, missiles, and bombers; converting bomb-grade uranium into civilian nuclear reactor fuel; and enabling nuclear weapons scientists to pursue civilian careers.

This is money wisely spent. I remember well the state of the Russian nuclear

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COUNTRY	WEAPON TOTAL
United States.....	10,100
Russia.....	16,000
France.....	350
Britain.....	200
China.....	200
Israel.....	75–200
India.....	40–50
Pakistan.....	24–48

SOURCE: ESTIMATES DERIVED FROM BULLETIN/NATURAL RESOURCES DEFENSE COUNCIL NUCLEAR NOTEBOOK DATA.

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establishment during the bleak decade of the 1990s. Fears of loose nukes were fully justified after the breakup of the Soviet Union, as were other specters: unauthorized seizure, coups d'état, nuclear diffusion among the former Soviet states, and launch on false warning issued by deteriorating early warning networks.

Nuclear safeguards were malfunctioning for want of spare parts and maintenance. The military was disintegrating, and nuclear scientists were struggling to feed their families. Nuclear security guards were desperately underpaid. At one point, about 80 percent of the families of the Russian strategic rocket troops were living below the official poverty line. For several years, everyone I met in the nuclear forces in Moscow was moonlighting driving a taxi or performing some menial job on one shift, and on the next shift standing nuclear duties or manning early warning sites all blinky-eyed from lack of sleep. They were receiving too little training to operate nuclear weapons safely. The nuclear bomber pilots, for instance, were getting about 10 hours of airborne flight training per year, barely enough to land a plane safely, much less fly them with nuclear bombs onboard, as compared to

200 hours for U.S. strategic bomber crews. In short, Russia's nuclear arsenal was an accident, theft, or inadvertent launch waiting to happen.

In terms of preventing theft, the Nunn-Lugar effort has made considerable progress. More than half of the Russian weapons and materials facilities (some experts say 80 percent) are now under more stringent safeguards. Military morale and well-being in the Russian nuclear sector are also being steadily restored, thanks to oil profits filling the government coffers and Russian President Vladimir Putin's increases in military spending.

But a large portion of Russia's nuclear stockpile remains insecure and will remain so for many years. The deterioration of nuclear forces and command-and-control systems has been arrested but not reversed. As long as the United States and Russia continue to operate their nuclear forces on a Cold War footing, their cooperative efforts to secure the Russian stockpile from theft or unauthorized use will fail.

There are two competing priorities here. One is the Nunn-Lugar effort to "lockdown" the Russian stockpile at fixed, secure locations. The other, in both Russia and the United States, is to maintain standard deterrent postures in which each side's nuclear forces stand ready at all times to fight a large-scale nuclear war with the other.

Nuclear aftermath

The more than 26,000 nuclear weapons spread across the globe have the potential to devastate the world's population and make vast areas of land uninhabitable. A summary of some of the effects of nuclear weapons, by the numbers:

477,713 The number of fatalities within a 5-kilometer (3-mile) radius of a single 15-kiloton (the yield of the Hiroshima bomb) airburst above Mumbai, India; 228,648 people would be severely injured.

130,000 The number of fatalities within a 43-kilometer (27-mile) radius of a single 1-megaton nuclear weapon detonated on the surface of Detroit during a workday; only 20,000 of the 250,000 inhabitants in the area would be uninjured.

290 The peak wind velocity (miles per hour) within a 5-kilometer (3-mile) radius of a 1-megaton airburst.

8 The minimum number of years it would take ground zero to return to background levels of radiation after the Detroit detonation, assuming no decontamination.

19 The number of 475-kiloton warheads required to wipe out 25 percent of Britain's 1999 population.

9 The kilometer radius within which mass fires can be expected from a 475-kiloton airburst in an urban area.

5,000 The approximate megatonnage of global nuclear arsenals.

4.5 The duration, in days, of a 5,000-megaton war, in which one Hiroshima-sized bomb was dropped every second.

250,000+ The number of people who could be exposed to significant levels of fallout if a 400-kiloton earth-penetrating nuclear weapon were dropped on North Korea's Pukch'ang air base.

SOURCES: OFFICE OF TECHNOLOGY ASSESSMENT, "THE EFFECTS OF NUCLEAR WAR," 1979; NATURAL RESOURCES DEFENSE COUNCIL (NRDC), "THE U.S. NUCLEAR WAR PLAN: A TIME FOR CHANGE," 2001; MATTHEW MCKENZIE ET AL., "THE RISKS AND CONSEQUENCES OF NUCLEAR WAR IN SOUTH ASIA," IN *OUT OF THE NUCLEAR SHADOW* (2001); CARNegie ENDOWMENT FOR INTERNATIONAL PEACE; DEPARTMENT OF MILITARY AFFAIRS, STATE OF MONTANA; NRDC.

Contrary to popular belief, the two sides still aim thousands of nuclear weapons at each other to satisfy nuclear guidance from both the Kremlin and the White House.

To understand how these priorities work at cross-purposes, it helps to be familiar with how nuclear forces are operated today. First, portions of both nations' strategic missile arsenals are kept on hair-trigger alert. If both sides sent the launch order right now, out of the blue, without any warning or preparation, thousands of nuclear weapons—the equivalent in explosive firepower of about 70,000 Hiroshima bombs—could be unleashed within a few minutes.

Second, if early warning satellites or ground radar detected missiles in flight, both sides would attempt to assess whether a real nuclear attack was under way within a strict and short deadline. Under Cold War procedures that are still in practice today, early warning crews manning their consoles 24/7 have only three minutes to reach a preliminary conclusion. Many people imagine that such occurrences never happen, or only rarely. But in reality, it happens practically on a daily basis, sometimes more than once per day, because there are many events involving apparent missile launches that require evaluation. I was visiting the North American Aerospace Defense Command in Colorado on New Year's Eve in 1999 when an event occurred that demanded such a threat assessment. At the conclusion of the incident, the early warning team emerged to report that the Russians had just launched a Scud missile into Chechnya. Other almost daily events include situations such as Japan launching a missile to put a satellite in orbit or a North Korean missile test.

Third, if an apparent nuclear missile threat is perceived, then an emergency teleconference would be convened between the president and his top nuclear advisers. On the U.S. side, the top officer on duty at Strategic Command in Omaha, Nebraska, would brief the president on his nuclear options and their consequences. That officer is allowed all of 30 seconds to deliver the briefing.

Then the U.S. or Russian president would have to decide whether to retaliate, and since the command systems on both sides have long been geared for launch-on-warning, the presidents would have little spare time if they desired to get retaliatory nuclear missiles off the ground before they—and possibly the presidents themselves—were vaporized. On the U.S. side, the time allowed to decide would range between zero and 12 minutes, depending on the scenario. Russia operates under even tighter deadlines because of the short flight time of U.S. Trident submarine missiles on forward patrol in the North Atlantic.

It is surprising to many people that so much firepower, representing such an apocalyptic threat, remains cocked on a hair trigger. Such rapid implementation of war plans would amount to going to war by checklist, enacting a prepared script of launch-on-warning that leaves no room for real deliberation, rational thought, or national leadership. Even in today's post-Cold War political environment with

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Political imbroglios

BERLIN CRISIS (SUMMER 1961). The Soviets push for control of Berlin. President John F. Kennedy mulls over his nuclear options while remaining fiercely protective of Western interests in the city. "We cannot and will not permit the Communists to drive us out of Berlin, either gradually or by force," he tells the American public in a July televised address. "For the fulfillment of our pledge to that city is essential to the morale and security of Western Germany, to the unity of Western Europe, and to the faith of the entire free world."

CUBAN MISSILE CRISIS (OCTOBER 1962). For 13 days, the world teeters on the edge of all-out nuclear war, as Kennedy confronts the Soviets about their nuclear weapon installations in Cuba. Heightening the tension further, both nations conduct intercontinental ballistic missile tests during the standoff. "I found myself in the difficult position of having to decide on a course of action which would answer the American threat but which would also avoid war," Soviet Premier Nikita Khrushchev wrote in *Khrushchev Remembers*. "Any fool can start a war, and once he's done so, even the wisest of men are helpless to stop it—especially if it's a nuclear war."

SOVIET-SINO FEUD (1969). Border skirmishes escalate into Soviet hints of severe—and potentially nuclear—retaliation. "[KGB officer Boris] Davydov asked point-blank what the U.S. would do if the Soviet Union attacked and destroyed China's nuclear installations," read an August 1969 State Department memo written by then-Special Assistant for North Vietnam William Stearman. "I replied by asking him if he really meant this to be a serious question. He assured me that he was completely serious and went on to elaborate."

YOM KIPPUR WAR (OCTOBER 1973). After Israel mobilized its nuclear forces during the war's opening stages, the United States follows suit in the fighting's waning moments, placing its nuclear forces on high alert when Soviet Premier Leonid Brezhnev implies his country might enter the conflict. The move worried even staunch U.S. allies. Per a British Joint Intelligence Committee assessment, "We are inclined to see the U.S. response as higher than necessary to achieve the desired effect."

KARGIL CONFLICT (1999). The long-standing Kashmir dispute receives a nuclear sheen, with both countries supposedly ready to launch their nuclear missiles after yet another clash in the contested mountain region. Two years later, tensions rise again, following a terrorist attack on the Indian parliament. "Who will strike first?" asks the *Economist*.

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Watching and waiting:
Inside NORAD.



False alarms

DANGEROUS COINCIDENCE (NOVEMBER 1956). In arguably the most frigid days of the Cold War, a collection of perilous happenstances registered by U.S. early warning centers (an unidentified jet in Turkish airspace, Soviet MiGs prowling Syria, and rumors of bellicose Soviet naval maneuvers) prompts the United States to twitch its nuclear trigger finger.

TALE OF THE WRONG TAPE (NOVEMBER 9, 1979). North American Aerospace Defense Command (NORAD) computers show a full-scale, preemptive Soviet strike against U.S. nuclear positions under way. For six minutes—before recognizing it as a false alarm—U.S. military officers fear the worst. The culprit: a NORAD technician who mistakenly loaded a simulation into the system without marking it as such.

A SOVIET GLITCH (SEPTEMBER 26, 1983). The Soviet early warning system indicates that the United States has launched five nuclear missiles at the Soviet Union. Disobeying orders, Stanislav Petrov, a lieutenant colonel in the Soviet Strategic Rocket Forces, decides against informing his superiors, correctly thinking a system malfunction occurred. "I couldn't believe that all of a sudden someone would hurl five missiles at us," Petrov told *Mosnews.com* in 2004. "Five missiles wouldn't wipe us out. The U.S. had not five, but a thousand missiles in battle readiness."

A RESEARCH ERROR (JANUARY 25, 1995). A communiqué from the Norwegian government detailing the launch of a research rocket intended to gather scientific information about the Northern Lights never reaches the Russian military. Without the warning, Russian radar operators—for a few minutes at least—believe they may be under nuclear attack when the rocket begins behaving like a U.S. Trident missile.

relatively good relations between Russia and the United States, there is inherent risk of human or technical error that results in a mistaken or unauthorized launch.

What is less well understood is that this nuclear dynamic absolutely precludes "locking down" Russia's nuclear arsenal in the way envisioned by the Nunn-Lugar program. Russia's warfighting nuclear posture keeps many hundreds of weapons in transit or temporary storage at any time. Far-flung mobile combat forces are in constant motion, and nuclear bombs are being constantly shuttled back and forth between their combat field locations and bomb remanufacturing facilities thousands of miles away. By truck, train, helicopter, and van the Russian bombs are constantly moving across 10 time zones.

And transportation is the phase in a nuclear bomb's life cycle in which it is most susceptible to capture or theft. That is the Achilles' heel of Russian nuclear security. Nunn-Lugar focuses on stationary weapons, in storage, and does not alleviate this risk at all. How long before a weapon in transit is stolen? If scores of heavily armed Chechens can travel to Moscow and seize a theater, could they also travel comparable distances to missile fields, seize a mobile intercontinental ballistic missile (ICBM) on patrol, circumvent the launch safeguards, and then fire it? Or could they hijack a truck or train car loaded with nuclear bombs being shipped over long distances to refurbishing plants? In pondering these questions, it is worth reflecting upon the fact that all nuclear safeguards are rated for their effectiveness in thwarting circumvention only for a temporary period of time. No safeguard can foil circumvention forever if the weapon remains under terrorist control.

Keeping hundreds of missiles on hair-trigger alert—armed, fueled, targeted, and poised to launch as soon as they receive two or three short, coded computer commands—also raises the question of whether they could be fired by unauthorized actors who manage to hack into the nuclear communications networks or even the actual launch circuits. It may not be as farfetched as many think.

Let me offer some food for thought: During the 1990s, an in-depth investigation of U.S. nuclear weapons safeguards conducted by the Federal Advisory Committee on Nuclear Failsafe and Risk Reduction found several deficiencies that terrorists could exploit to gain some control over the weapons. For instance, the committee found an electronic backdoor to the naval communications network used to transmit launch orders to U.S. Trident missile submarines. Unauthorized individuals, including terrorists, could have hacked into the network, seized control over land-based naval transmitters, and sent a nuclear launch order over the airwaves to the subs. This deficiency was deemed so serious that Trident crews were given radically new instructions on how to ensure that a launch order is valid.

Today, military computers are constantly under assault by hackers, and the vulnerability of nuclear command,

control, early warning, and communications systems to unauthorized electronic intrusion is worthy of serious concern and analysis. In my experience, the deficiencies in these networks defy comprehensive discovery, and evaluating their danger is highly complex, particularly when assumptions about the nature of "insider" collusion are varied.

Why take these real risks for unnecessary, anachronistic deterrent purposes? The United States and Russia could greatly strengthen their nuclear security and safeguards (and demonstrate their commitment to honoring their pledges to pursue nuclear disarmament as required by treaties in force) by standing down their nuclear missiles, taking them off of hair-trigger alert, and extending the time needed to launch them from the current period of seconds to a much longer period of days, weeks, and eventually years. By physically de-alerting their forces, the two nuclear rivals would buy a large margin of safety against a host of dangers and risks of an apocalyptic magnitude. De-alerting would also allow nuclear weapons to be locked down and secured through Nunn-Lugar and would virtually eliminate risks of theft and unauthorized or inadvertent missile launch.

Russia and the United States need to deepen their cooperation beyond Nunn-Lugar and realign their nuclear postures to fit with the current political reality, for the sake of nuclear security on both sides. This has become clear to me in personal terms through hundreds of conversations with Russian nuclear experts over the past two decades. It was driven home most vividly on New Year's Eve, 1999, when I joined up with a group of Russian and U.S. military officers in Colorado.

Readers may remember that our countries set up a joint center there to monitor the rollover from 1999 to 2000, in order to prevent an accidental nuclear war from being triggered by the computer bug dubbed Y2K. Despite spending billions of dollars to rid their military and intelligence computer networks of this so-called millennium bug, the two countries took the additional precaution of bringing their early warning officers together to jointly interpret the near real-time data from U.S. satellite and ground radars used to detect enemy missile launches. These officers' job was to diagnose any missile launch reports coming from these sensors during the rollover period, to ensure that they were not caused by Y2K bugs. I was allowed to watch this joint operation as the clock ticked down to midnight around the world. We were, of course, all jubilant as the rollover proceeded without a hitch from one time zone to another, moving from Russia west through Europe and the United States. I was there at the moment of truth for U.S. nuclear control, when the clock struck midnight Greenwich mean time without any false alarms from our missile attack warning sensors or any computer-induced accidental launches of strategic missiles.

This joint center was actually a prototype for a permanent joint center that was to be built in a Moscow sub-

urb. Its purpose was not only to prevent false alarms of nuclear missile attacks from triggering World War III, but also to share intelligence and real-time data on ballistic missiles being developed and tested by proliferant states such as Iraq, Iran, North Korea, and many others. If we had finished building this joint center, today both the United States and Russia would be closely monitoring the test of North Korea's Taepodong II ICBM, which is being designed to loft a nuclear bomb to targets many thousands of miles away. We would be jointly tracking nuclear missile proliferation around the world. We could have invited China and other interested parties to become partners in the venture.

The center unfortunately was not built, stalled over a minor dispute about who would assume liability for construction accidents. This is one small but telling indicator of the level of priority actually accorded nuclear safety and proliferation by the White House and the Kremlin. It is lower than most people realize. If we were really serious about it, and wise, we would end the nuclear hair-trigger status quo, de-alert, cut the liability knot, and open this joint center in Moscow. *

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A damaging designation

BY WOLFGANG K. H. PANOFSKY

The deadly semantics of
"weapons of mass destruction."

IRONICALLY, THE TERM "WEAPONS OF MASS DESTRUCTION" (WMD) was first used to describe an attack with conventional weapons—the 1937 German cluster-bomb attack against the city of Guernica during the Spanish Civil War. Since then, WMD has been applied to unconventional weapons, including nuclear, chemical, and biological arms. This terminology is most unfortunate, since these three categories of weapons are very different as measured by their legal status, their physical effects, the evolution over time of their effects, the potential of preventive and remedial measures to mitigate their damage, and the ease of hiding their production and deployment.

If the only complaint against the term WMD were an error of nomenclature, then this oversimplification might

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be pardoned as merely an illogical use of the English language. Unfortunately, the problem is more serious. This commonality of designation has severely inhibited efforts to control the most lethal and destructive weapons now deployed: nuclear weapons.

Chemical weapons (CW) do not merit inclusion in the category of WMD under any circumstances. The effects of CW as measured in terms of lethality per unit weight or size carried by specified munitions are not significantly different from those delivered by conventional explosives. And whereas biological weapons (BW) have the potential of enormous lethality stemming from advances in biotechnology and genetic engineering, they have not been used in warfare except in very limited instances. The means of delivering BW are complex and pose risks to the attacking party. And while very little can be done to alleviate the devastation wrought by a nuclear attack, a host of protective measures—including specialized clothing, respiratory equipment, vaccines, and other public health initiatives—exist to mitigate a BW attack.

Nuclear weapons have not been used in war for more than 60 years, and no atmospheric nuclear explosions have occurred since the Limited Nuclear Test Ban Treaty of 1963. Yet governments worldwide still cling to their nuclear arsenals, or seek to acquire them. Today's decision makers regard them as symbols of national strength or even of international prestige. This symbolism itself incurs dangers, since it can weaken the taboo against using nuclear weapons and mask the reality of their destructive power from the public.

That reality is awesome indeed. In 1945, just two nuclear weapons—possessing an average energy that was

one-twentieth of the average yield of the weapons in today's U.S. and Russian stockpiles—killed a quarter of a million human beings in Hiroshima and Nagasaki. Nuclear weapons kill through immediate effects—in particular blast, heat, and prompt radiation as well as delayed effects. A 1-megaton nuclear explosion produces a lethal blast of about 70 kilopascals (10 pounds per square inch) at a distance of more than 1.6 kilometers (1 mile), killing exposed human beings over an area of about 7.8 square kilometers (3 square miles). The delayed effects of this explosion, including radioactive fallout and devastating fires, increase this lethality by a major factor.

An international norm against stockpiling or using chemical or biological weapons exists in the form of the Chemical Weapons Convention and the Biological and Toxin Weapons Convention. But no equivalent norm exists forbidding the stockpiling of nuclear weapons. Those stockpiles grew to a total of about 70,000 during the height of the Cold War and have now been reduced to fewer than 27,000—still an insane number. The Cold War is over, but nuclear risks remain in the form of accidental, inadvertent, or unauthorized use between Russia and the United States, regional use such as between India and Pakistan, and the possibility that weapons-usable fissile materials or nuclear weapons themselves will find their way into the hands of terrorists.

Proliferation of nuclear weapons has been retarded but not prevented through the Nuclear Non-Proliferation Treaty (NPT), which came into force in 1970. This treaty delineates a well-known bargain that nations not now possessing nuclear weapons will forego efforts to acquire them if the existing nuclear weapon states make a good faith effort toward elimination of their arsenals, and if non-nuclear weapon states can have unfettered access to peaceful applications of nuclear energy. All but



EXPERT TESTIMONY

Old habits die hard

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U.S. and Russian nuclear forces were created during the Cold War, and both countries have preserved most of their operational practices, thinking, and structure. As long as the technical capability is there, there will be a danger of an accident or some kind of a misunderstanding, miscalculation, or error.

We should not lightly dismiss the possibility of these kinds of things from happening. Neither should we overestimate the progress that we have made in changing the Cold War mind-set. The September 11, 2001, terrorist attacks occurred 10 years after the end of the Cold War. Yet, the lead pilot of the fighter squadron dispatched to intercept the hijacked planes later testified to the 9/11 Commission, "I reverted to the Russian threat. . . . I'm thinking cruise missile threat from the sea. You know you look down and see the Pentagon burning, and I thought the bastards snuck one by us."

Also, on that same day, the North American Aerospace Defense Command was scheduled to conduct an exercise, known as Vigilant Guardian, "which postulated a bomber attack from the former Soviet Union." And Russia was in the middle of a strategic bomber exercise that involved flights in the direction of the United States. The Russian military terminated that exercise as soon as they learned about the events in the United States. But the number of coincidences on the day of the terrorist attacks is quite alarming.

four of the nations on this globe are parties to this treaty. Yet the NPT is under severe stress today, both due to the continuing reliance of the nuclear weapon states on their arsenals in the conduct of international relations and due to the potential of some non-nuclear weapon states to join the nuclear weapons club. Ultimately, proliferation can be stopped only if all non-nuclear weapon states are persuaded that their national security is served better without nuclear weapons than through their possession.

Essential ingredients to promoting that latter conviction can take the form of both negative and positive security assurances. Positive security assurances provide that nuclear weapon states will assist non-nuclear weapon states should they be attacked by a nuclear-armed aggressor. Negative security assurances embody a guarantee that nuclear weapon states will not attack non-nuclear weapon states with nuclear weapons. In 1978 and 1995, the Carter and Clinton administrations explicitly made such a pledge. The United States promised not to use nuclear weapons except: in response to attacks on the United States or its military forces by nuclear-capable states; in response to attacks on the United States or its military forces or allies by non-nuclear weapon states allied with a nuclear weapon state; or in response to attacks by a non-nuclear weapon state “not in good standing” under the NPT. Specifically, these negative security assurances implicitly included a guarantee not to retaliate with nuclear weapons even if a non-nuclear weapon state used chemical or biological weapons.

But recent U.S. government statements have diluted that guarantee. The Bush administration has sought to develop earth-penetrating nuclear weapons, ostensibly to launch preemptive strikes against underground stockpiles of biological and chemical weapons. And the White House declared in December 2002, “The United States will continue to make clear that it reserves the right to respond with overwhelming force—including through resort to all of our options—to the use of WMD against the United States, our forces abroad, and friends and allies.” In effect, by expanding the definition of WMD to encompass biological and chemical weapons, the United States has proclaimed new rationales for using nuclear weapons. In doing so, the United States emasculated its negative security assurances and thereby seriously undermined the nonproliferation regime by sending the clear message that nuclear weapons are vital to a nation’s security.

Seen in this light, the inclusive concept of WMD is not only illogical but has damaged efforts to stem the spread of the one and only true weapon of mass destruction. *

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Lost bomb: A U.S. search for a hydrogen bomb off the coast of Spain in 1966.



Broken arrows

WAR SCARE (NOVEMBER 10, 1950). An in-flight emergency causes a B-50 bomber to drop its payload from 10,500 feet into Quebec’s St. Lawrence River. None of the weapons contains a nuclear capsule, but the conventional payloads detonate; many think it’s the opening salvo of war. Although later included in its “Narrative Summaries of Accidents Involving U.S. Nuclear Weapons, 1950–1980,” the Pentagon provides a cover story to calm nervous locals.

FIRE IN THE HOLE (JANUARY 31, 1958). The left rear wheel casting of a B-47 with a nuclear weapon on board gives way while taking off from Greenham Common Air Base in Britain, rupturing a fuel tank. The ensuing fire burns for hours. Although the nuclear weapon doesn’t detonate, 10–20 grams of powdered uranium and plutonium oxide spreads throughout the immediate vicinity.

LIGHTNING STRIKING, AGAIN AND AGAIN (MID-OCTOBER 1961–AUGUST 1962). Jupiter missiles equipped with nuclear warheads based in Italy prove to be magnets for lightning, getting struck four times over the course of almost a year. The lightning partially arms two of the missiles.

MIDAIR COLLISION (JANUARY 17, 1966). Near Palomares, Spain, a B-52 carrying four nuclear weapons crashes after colliding with another aircraft. The U.S. military eventually recovers the explosive quartet, but authorities discover that two of the bombs leaked plutonium upon impact, forcing the United States to remove 1,400 tons of radioactive soil. The U.S. and Spanish governments recently undertook another cleanup effort after finding high levels of radioactivity in snails near the crash site.

ROUGH LANDING (JANUARY 21, 1968). A B-52 shorts the runway while landing at Thule Air Base in Greenland. The ensuing fire destroys the four nuclear weapons aboard and spreads radioactivity around the surrounding sea ice, snow, and water. The United States removes 237,000 cubic feet of contaminated material.