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INDONESIA EXPANDING REGIONAL LINEUP

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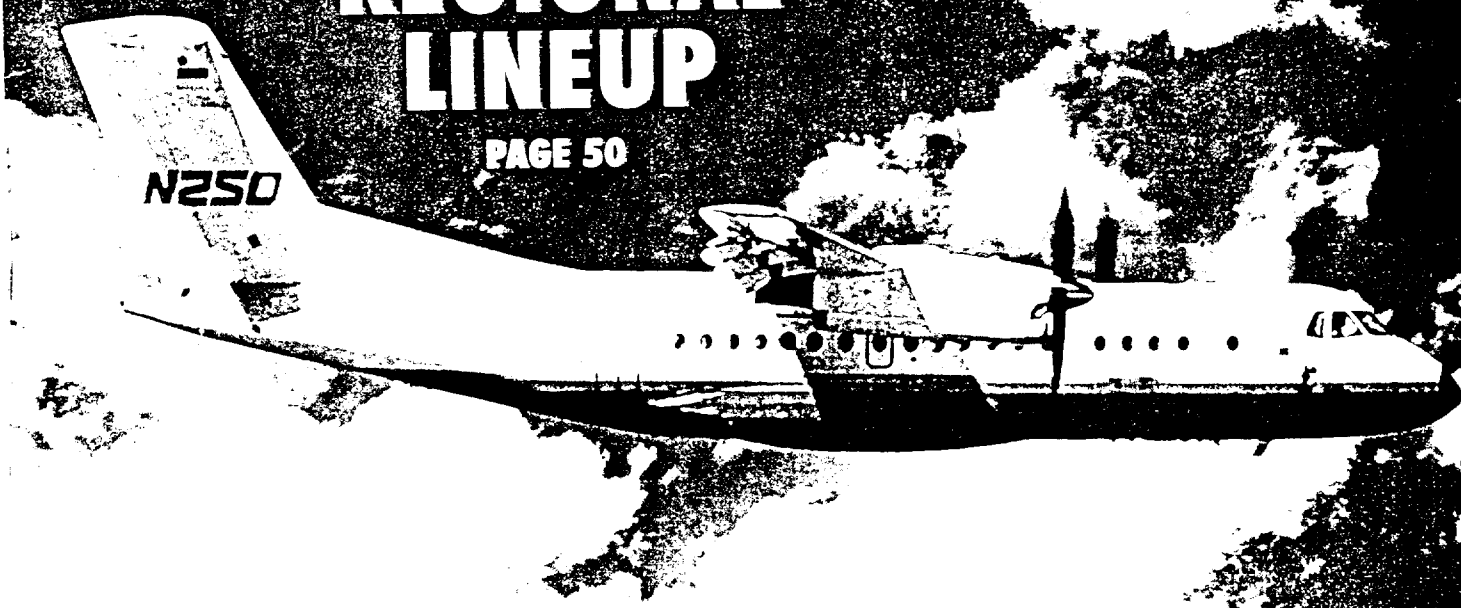

POST-COLD WAR NIGHTMARE

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POST-COLD WAR NIGHTMARE

Mass Weapons Threat Deepens Worldwide

PAUL MANN/WASHINGTON

Most ex-Soviet nuclear facilities are no more secure now than in 1991, and experts fear mass urban deaths from terrorist nuclear, biological and chemical attacks

A specialized form of warfare has become America's number one national security challenge, and it knows no boundaries, according to high-ranking U.S. authorities from many fields.

The deepening threat, they claim, is the terrorist use of nuclear, biological and chemical weapons to inflict mass urban casualties and social paralysis almost anywhere in the world. Such weapons might also be used to gain a decisive edge in a regional war.

In light of last year's nerve gas assault on a Tokyo subway, the terrorist explosion in Oklahoma City and the persistence of nuclear smuggling incidents out of the former Soviet Union, U.S. authorities in government, defense, intelligence, law enforcement, science and medicine believe worse is to come, and soon.

AS EVIDENCE, THEY CITE the fact that more fissile material is known to have been stolen from the former Soviet Union than the U.S. produced in the first three years of the Manhattan Project to build an atomic bomb during World War 2. They also cite the precedent-shattering nature of the chemical warfare attack in Tokyo by the Japanese Aum Shin Rikyo religious cult in March, 1995. That assault proved that "the use of weapons of mass destruction is no longer restricted to the battlefield," says a ranking U.S. intelligence official.

The boundary between military and civilian warfare is blurring again, on a worldwide scale. Officials compare the spread of weapons of mass destruction to the epidemic of illegal drugs.

The Central Intelligence Agency is predicting "a tremendous increase" in international terrorism of all kinds during the next 10 years. Top-ranking officials from Los Alamos National Laboratory told Congress in March there are over 20 countries suspected of some form of nuclear, biological or chemical proliferation. They testified that the proliferation of weapons of mass destruction (WMD) has recently become "the most urgent and direct threat to national security."

In an April report, Defense Secretary William R. Perry declared that "the proliferation of these horrific weapons presents a grave and urgent risk to the United States and our citizens, allies and troops abroad. Reducing this risk is an absolute priority."

Experts warn that in the near term, the terrorist use of WMD is less likely to be mounted by costly missiles, drones and unmanned aerial vehicles than by cheap means that are part of everyday life. An urban assault might arrive from above by crop duster (chemical warfare), from within a subway by a purse-size perfume atomizer (biological warfare) or in a suitcase (nuclear warfare).

U.S. Sen. Sam Nunn (D.-Ga.): "We've seen that small groups can disrupt society on a massive scale. . . . We are becoming more and more vulnerable to this threat."

The Japanese cult sought to obtain aircraft and helicopters for dissemination purposes, as well as other delivery systems. This occurred "right under the noses of their own government and numerous foreign intelligence services," admonishes Sen. Sam Nunn (D.-Ga.), a congressional authority on national security matters.

"Nuclear, chemical and biological weapons, materials and know-how are now more available to terrorists and rogue nations than at any other time in our history," says Sen. Richard Lugar (R.-Ind.). "Domestically, we here in the U.S. are not equipped to manage the crisis that would be imposed by the threatened use of such weapons or handle the consequences of such use against civilian populations."

Under Secretary of the Navy Richard Danzig believes the perception that American society is reluctant to accept high mortality rates in combat will make high-casualty weapons, such as biological agents, especially attractive to enemies.

Government and private sector specialists express confidence that an array of forthcoming technologies, in particular advanced sensors, will strengthen counterproliferation efforts (see story p. 66). But they concede—and lament—that such projects are underfunded and years late, especially in the biological and chemical arena.

PARADOXICALLY, THE STRUGGLE to catch up is jeopardized by advances in science. At a proliferation conference here late last month cosponsored by Los Alamos and Harvard University's Center for Science and International Affairs, specialists outlined profoundly complex moral as well as security dilemmas for the none-too-distant future.

Warns Matthew S. Meselson, a molecular geneticist and biological/chemical warfare specialist at Harvard: "We're going to learn how to manipulate every life process, genetic ones, mental ones, the emotional ones. . . . If our inevitably increasing knowledge of life processes is also harnessed to hostile purposes, that will completely change the nature of the expression of human hostility. We will face something that we don't even know how to describe now."

Adds C. Paul Robinson, president and laboratory director of Sandia National Laboratories: "The known possibilities to devise very complex biological species through genetic engineering, or to harness

natural toxins, bacteria and viruses for weapons or terrorist use, complicate the problem of developing defenses. . . . It is most likely that it will be necessary to develop sensors that can differentiate between individual DNA components."

Traditionally, WMD weapons have been thought of in purely military terms. But potential aggressors who are too weak to challenge America's overwhelming conventional and nuclear military power on the battlefield almost certainly will attack the U.S. indirectly and by stealth, officials say.

Rogue nations, terrorists, subnational groups, cells of ethnic or religious zealots, even individuals with a grudge, are expected to attempt mass urban panic and destruction with relatively simple nuclear devices or with widely accessible chemical and biological agents. The chemicals used to make nerve agents, for example, are also used to make plastics and foodstuffs. Biological weapons can be derived from any reasonably developed pharmaceutical industry.

"Terrorism used to be a theater to attract attention," says Nobel Prize winner and research geneticist Joshua Lederberg. It still is, but now "there are many groups who are really out to get as many people as possible and do as much harm as possible."

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Terrorist use and nation-state use of WMD are old concerns, anticipated by countless Pentagon threat estimates going back decades. Washington insiders charge that such estimates are as changeable as weather forecasts, especially at springtime, when the annual congressional budget process begins in earnest. Executive agencies besiege lawmakers with forecasts of dire consequences if Administration budget requests are not met.

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Further, the threat is more deeply entrenched and mature than U.S. authorities realized before the belated disclosure last summer that the extent of Iraq's biological warfare effort was substantially greater than earlier suspected.

Official concern also has deepened because the steps the U.S. government has taken to contain the threat have been halting and moved slower than authorities had hoped. Illustrative, they say, have been the chronic delays in securing and dismantling Russia's enormous nuclear stockpile under the Nunn-Lugar program for cooperative threat reduction (see p. 64).

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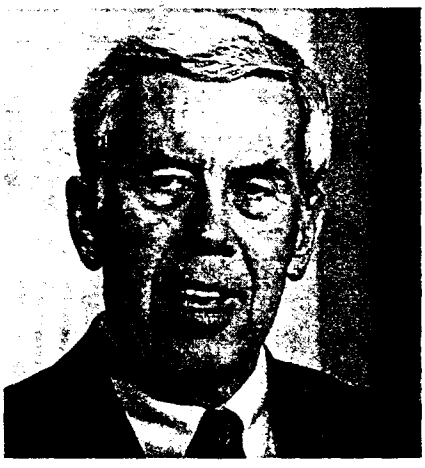

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to Minatom, Moscow's counterpart to the U.S. Energy Dept. Minatom's security standards "do not even approach weapons standard." The change in custody represents a proliferation nightmare of "epic proportions."

According to Harvard's research, there are six known cases since 1992 of theft or illicit trafficking in fissile material, two in Russia, three in Germany and one in the Czech Republic. (A suspect in a seventh case was arrested in Munich early this month.) In one instance, a Russian navy captain stole about 10 lb. of HEU from a submarine fuel storage facility in Murmansk in November, 1993.

WHAT PUTS THESE SIX incidents into historical perspective, the study asserts, is that today "more fissile material is known to have been stolen from the former Soviet Union than the United States managed to produce in the first three years of the Manhattan Project."

Strategic analysts at Harvard and elsewhere call urgent attention to the fact that interceptions to date have taken place on Russia's Western borders. Knowledgeable officials are extremely worried that nuclear leakage and smuggling have occurred undetected on Russia's eastern and southern periphery, which they say is grossly under-policed.

The Harvard analysis, titled "Avoiding Nuclear Anarchy," zeroes in on four actions the U.S. should accelerate or initiate to achieve the greatest possible reduction in the nuclear leakage threat in the shortest possible time:

- Do whatever is necessary to implement and accelerate better security at all former Soviet nuclear installations.
- Propose a high-priority joint inventory and site-by-site security analysis of all U.S. and Russian installations.
- Expand and accelerate the U.S. purchase of Russian HEU.
- Offer to buy Russia's excess weapons-grade plutonium.

But the study holds out little hope of dramatic action by Washington, owing to tight budgets, partisan bickering and lack of political will. Few of the many measures that could help prevent leakage and smuggling "have much prospect of getting a serious hearing in the climate of massive deficits, deep budget cuts, partisan rivalry, electoral calculations and shrinking imagination."

American policymakers performed well in corralling the Soviet empire's tactical and strategic nuclear weapons when it collapsed, the study agrees. But it says Washington has made distressingly little progress in securing the remnants of the Soviet nuclear legacy, now located principally in Russia.

Unquestionably, a large part of the problem is money. In the period 1991-95, the study says, the U.S. spent $400 million annually—less than two-tenths of one percent of the defense budget—on containment. Only a fraction of that has been spent on helping Russia to enhance the security of its nuclear materials.

The political obstacle to efforts such as the Nunn-Lugar cooperative threat reduction program with Russia is that many lawmakers, especially House Republicans, regard them as foreign aid, not as a national security investment. Foreign aid perennially has had a bad reputation on Capitol Hill as a drain on pressing domestic needs, except for assistance to Israel and Egypt. The end of the Cold War has heightened resistance to foreign aid.

Harvard's Graham T. Allison: The likelihood a nuclear weapon will explode on U.S. soil has gone up since the end of the Cold War.

"We're now in the 12th straight year of decline in real dollars in defense resources," says Gordon Adams, who is responsible for the national security and international affairs accounts at the White House Office of Management and Budget. "We are also about 50% in constant dollars below where we were 10 years ago in resources for international affairs. So when you get to the pockets of money that target this problem [of proliferation], the resource squeeze is very dramatic and real."

Some proliferation experts argue that defenses against biological and chemical warfare attacks are a more pressing budgetary and security need near-term than nuclear ones. Biological and chemical materials are readily available in the commercial market. But the Harvard analysis is singular in its insistence that nuclear leakage "constitutes the most serious direct threat to vital U.S. interests today and for the foreseeable future."

Authors Graham T. Allison, Owen R. Cote, Jr., Richard A. Falkenrath and Steven E. Miller readily acknowledge that their pessimism will come as a surprise to an American public confident that the Cold War is over. But they argue that the sense of security that has arisen from the ebbing threat of a global nuclear conflict masks "the single most important truth" of the post-Cold War era: that Russia is convulsed by a genuine, ongoing revolution.

FOR THE FIRST TIME IN history, they stress, a country possessing a superpower arsenal of nuclear weapons and fissile material is experiencing a revolutionary transformation of its government, economy and society. It is an upheaval "as profound as the French Revolution following 1789 that led to Napoleon's challenge to European security." In the midst of this turbulent change, the ex-Soviet nuclear stockpile is being stored in installations that lack adequate security, which are themselves located inside a highly unstable country. Neither American nor Russian leaders have begun to address this problem "in a manner commensurate with their stakes in the issue."

Allison, a special advisor to Defense Secretary William J. Perry and director of Harvard's Center for Science and International Affairs, hastens to point out that the threat is ecumenical. Russia is the next likely target of a terrorist incident, he predicts, because it is Russia that is home to the world's largest stockpiles of nuclear, biological and chemical weapons. And the Russian government "has a rather active civil war going on with the Chechens."

According to Allison and his colleagues, literally hundreds of incidents of alleged theft and illicit trafficking in nuclear materials and weapons from the former Soviet Union have been reported since 1991. The vast majority of the known incidents have been hoaxes or have not involved weapons-usable material. But the Harvard study insists nevertheless that the large number of both real and fraudulent sales attempts suggests a considerable effort to fill the supply side of an emerging nuclear black market.

Nuclear Smuggling Called Direct Threat to U.S.

PAUL MANN/WASHINGTON

Since the end of the Cold War, has the likelihood that a nuclear weapon will explode on U.S. soil gone up or gone down?

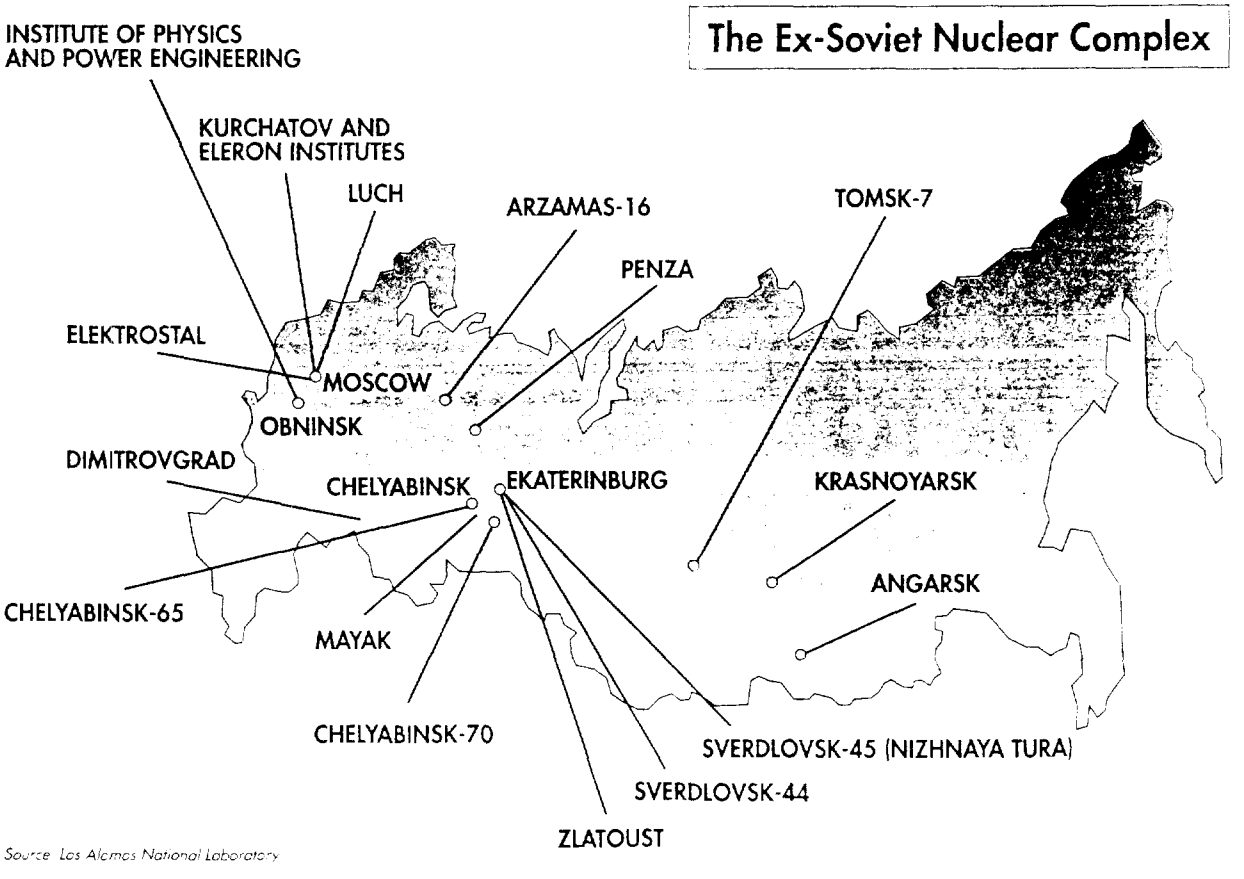
The answer of a new Harvard study is unequivocal—it has gone up.

Harvard's strategic analysts contend that either a state or a terrorist group could be ready in a matter of months to detonate a nuclear explosion with a budget of just a few hundred thousand dollars. The deed could be done with as little as a softball-sized 30 lb. of highly enriched uranium, with designs available on the Internet and with materials from retail stores like Radio Shack.

A nuclear explosion can be created with as little as 2.2 lb. of plutonium or 5.5 lb. of highly enriched uranium (HEU) in a sophisticated nuclear weapons program, according to the private Natural Resources Defense Council, a nonprofit environmental advocacy group based here and cited by the Harvard study.

With every passing day, the independent university study argues, the chances increase that nuclear materials being leaked or smuggled out of the former Soviet Union might lead to disastrous consequences. That conclusion is based on a wealth of findings, but four of the main ones are these:

- The continuing collapse of all central control systems in Russia and the ex-Soviet states leaves everything in them vulnerable to theft, seizure or loss. "Never before has such an enormous inventory of nuclear assets existed in such precarious circumstances."
- Security is poor at most of the several hundred locations where 100,000 nuclear weapons and weapons-usable nuclear "equivalents" of highly enriched uranium and plutonium remain scattered. At the Chelyabinsk-65 installation, bulk plutonium is stored in an old warehouse with glass windows and a padlock on the door.
- Russia has no national or site-specific inventory system for its fissile material. More of this material is stored in improvised, insecure facilities at Sverdlovsk (or at Chelyabinsk, Tomsk or Krasnoyarsk) than is contained in the entire stockpiles of Britain, France and China combined. The Russian administrative units that contain these installations are, respectively, the second, third, fourth and fifth largest nuclear powers in the world.
- The process of dismantling nuclear warheads under START (Strategic Arms Reduction Treaty) is overwhelming Russia's capacity to store the resulting excess weapons components. Warheads are being dismantled at the rate of 2,000-3,000 a year, and when they are, their custody shifts from the Russian defense ministry



Source: Los Alamos National Laboratory

you can only understand the defense if you can understand the offense. We don't do that well in either biological, chemical or on radiological [weapons]. As Heraclitus said around 500 B.C., 'He who does not expect the unexpected cannot detect it.'" (Radiological weapons employ conventional explosives to scatter radioactive material. They do not produce a nuclear explosion, but they do spread contamination.)

AUTHORITIES ALSO SAY the Tokyo assault demonstrated that terrorists and violent subnational groups need not acquire a large and expensive infrastructure to create a deadly arsenal. They can obtain what they seek legally, in a world economy that is now genuinely global. New free trade pacts and the loosening of export controls since the end of the Cold War in 1991; the accelerating spread of modern technology; the advent of the Internet and cyberspace; the expanding internationalization of crime—these offer would-be aggressors a "supermarket" of lethal opportunities.

"Visualize the World Trade Center or an Oklahoma City-style attack complicated by the inclusion of a kilogram of anthrax spores as a kind of microbiological shrapnel along with the explosives," suggests Nobel winner Lederberg. "And [imagine] its implications for salvage and rescue, public health, panic.

"If I just mention the word Ebola," he adds, "you have some idea of what I am talking about." Nunn reports that disciples of the Japanese cult sought to obtain the Ebola virus in Zaire and laser instruments and protein data bases for biological warfare in the U.S.

The nuclear threat is easier to define, and strategies and technologies to contain it are more mature, than its biological and chemical counterparts, officials say. But in the far-flung ex-Soviet nuclear complex, warns a new Harvard study, "Most of the relevant facilities are no more secure at the end of 1995 than they were when the Soviet Union disappeared" in December, 1991 (see p. 62).

Titled "Avoiding Nuclear Anarchy," the Harvard analysis also claims that the Oklahoma City and New York World Trade Center bombings could easily have been carried out with a suitcase containing 100 lb. of highly enriched uranium (HEU), rather than the mini-vans loaded with hundreds of pounds of crude explosives that the terrorists used. Had they acquired a simple, well-known weapon design using HEU, the terrorists could have inflicted a blast that would have been equivalent to 10,000-20,000 tons of TNT. "Much of Oklahoma City would have disappeared. The tip of Manhattan, including all of Wall Street reaching up to Gramercy Park, would have been destroyed."

SOME OFFICIALS PORTRAY mass urban terrorism with WMD as comparable in degree if not in extent to the threat of nuclear annihilation during the Cold War. Accordingly, leaders such as Lugar are urging mobilization efforts comparable to those of the Manhattan Project of the 1940s to build an atomic bomb. But officials acknowledge that the consensus on the threat is not matched by a consensus on the response.

Lugar, Nunn and Sen. Pete Domenici (R.-N.M.) are offering language to next year's defense budget to foster coherence in the scores of executive programs for containing the WMD threat (*AW&ST* May 27, p. 19). But they worry that the partisan feud in this year's presidential election over national missile defense will steal the spotlight from WMD terrorism, although the two are integral.

And in any case, the White House says the money simply does not exist for a Manhattan Project-style response.

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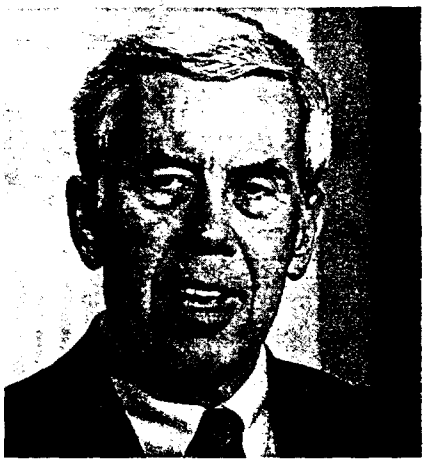

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Deficit Pressures Hobble Anti-Proliferation Efforts

PAUL MANN/WASHINGTON

Securing and dismantling the Soviet nuclear legacy at its source are the top funding priorities of America's nuclear stewards, who are hobbled by the same deficit pressures as the rest of the government.

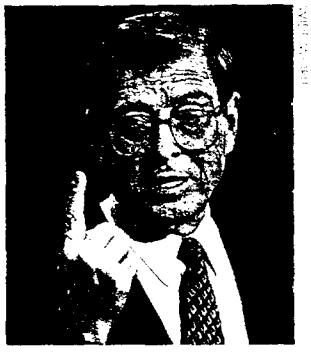
They say that in the battle of the budget, two programs are paramount for securing ex-Soviet nuclear materials and preventing smuggling. One is the Energy Dept.'s laboratory-to-laboratory collaboration with Russia's leading nuclear institutes, set up in 1994. Currently, six U.S. National Laboratories and all of the leading nuclear institutes in Russia are engaged in the lab-to-lab effort, according to Donald D. Cobb, director of nonproliferation and international security programs at Los Alamos National Laboratory, and Walter L. Kirchner, director of Defense Dept. programs at the New Mexico facility.

The second program is a counterpart, the Industrial Partnering Program (IPP), conceived by Sen. Pete Domenici (R.-N.M.), which is intended to help curb proliferation by finding jobs for the thousands of scientists and engineers thrown out of work in Russia and the Newly Independent States. The "brain drain" threat is no longer hypothetical, warns Sen. Sam Nunn (D.-Ga.). "Advertisements have appeared in foreign countries searching for out-of-work Soviet weapons scientists looking for new employment."

Conceived to steer Russia's scientific institutes toward economic self-sufficiency without dependence on U.S. financing, the IPP is used to encourage productive links among the Energy Dept.'s laboratories, U.S. industry and ex-Soviet scientific institutes, particularly those that were engaged in the development of weapons of mass destruction. Cobb and Kirchner told Congress in March that the IPP had engaged more than 2,000 scientists in 200 projects at 60 institutes. More than 90% have direct commercial relevance for U.S. firms, they claimed, and "over 80% benefit DOE programs."

They highlighted a project at the nuclear weapons institute Chelyabinsk-70. Advanced superplastic metal forming technology is being developed for the evaluation of more efficient methods to fabricate turbine blades for jet aircraft engines.

Both the lab-to-lab and IPP efforts fall under the rubric of the Energy Dept.'s Materials, Protection, Control and Accounting (MPC&A) program to assist the former Soviet states. The department plans to request $500 million for the program from Fiscal 1997 to Fiscal 2000 to finance MPC&A improvements at roughly 100 ex-Soviet facilities believed to house weapons-usable nuclear material. "Tons of material have been secured to date, [but] much more remains to be done," acknowledges Deputy Energy Secretary Charles B. Curtis.



Sen. Pete Domenici (R.-N.M.) conceived the Industrial Partnering Program to help deal with Russia's "brain drain."

The issue, he adds pointedly, is "budget, budget, budget." Curtis spoke late last month at a conference here on nuclear, biological and chemical weapons (NBC) proliferation, cosponsored by Los Alamos and Harvard University's Center for Science and International Affairs.

At the same conference, John P. Holdren, a professor of energy at the University of California, Berkeley, agreed that the MPC&A programs are proceeding well, after a slow start. He too believes they are underfunded. He said an appropriation of $150 million—about 50% higher than this year's level—would allow a more rapid reduction in the highest priority proliferation risks. He also urged the release of funding to carry out a congressional mandate on the Administration to pursue an agreement to end Russia's production of plutonium for weapons. Washington and Moscow signed an agreement in mid-1994 and affirmed it last January, but the money "is still not flowing," he said.

Holdren, a faculty consultant to the laser and energy directorates at Lawrence Livermore National Laboratory, and a member of President Clinton's Committee of Advisors on Science and Technology, estimated that MPC&A agreements on upgrading security and accounting systems now cover more than 70% of all the locations in the former Soviet Union where weapons-usable plutonium and highly enriched uranium are housed. But he said it is obvious that funding is short because the Energy Dept. program currently stretches to 2002.

Many analysts believe that is too long to wait in view of the mounting risks—resulting from Russia's political and economic turmoil—that the world's largest nuclear stockpile might be dispersed and wind up in terrorist, rogue nation or criminal hands.

Several authorities at the conference voiced strong concern that the U.S. focus on the former Soviet states and Central Europe has dangerously neglected the buttressing of law enforcement and border control of the crucial states to Russia's south, which Holdren described as "eager for cooperation in this area." This points to an overarching problem. Nearly five years after the Soviet empire fell in December, 1991, Holdren said, the U.S. still does not have a comprehensive approach to addressing the Soviet nuclear proliferation problem "or the funding needed for any such effort to succeed." He recommended:

- Creation of regional analysis centers in Eurasia, capable of both nuclear and traditional forensic analysis, where material seized in nearby countries could be sent.
- Provision of training and simple nuclear detection equipment to border guards and customs agents throughout the former Soviet Union—particularly the southern tier states—and Central Europe.
- Broader cooperation between U.S. intelligence and law enforcement agencies and their counterparts in Russia and other relevant states.

Los Alamos is home to a network called the Nuclear Supplier's Group Information Sharing System (NISS) that links more than 20 countries to share export control information. Los Alamos also maintains the Energy Dept.'s Proliferation Information Network System (PINS), which links the department and the National Laboratories to permit analysis of nuclear dual-use technology exports.

Detection Sensors Crucial, But Technically Exacting

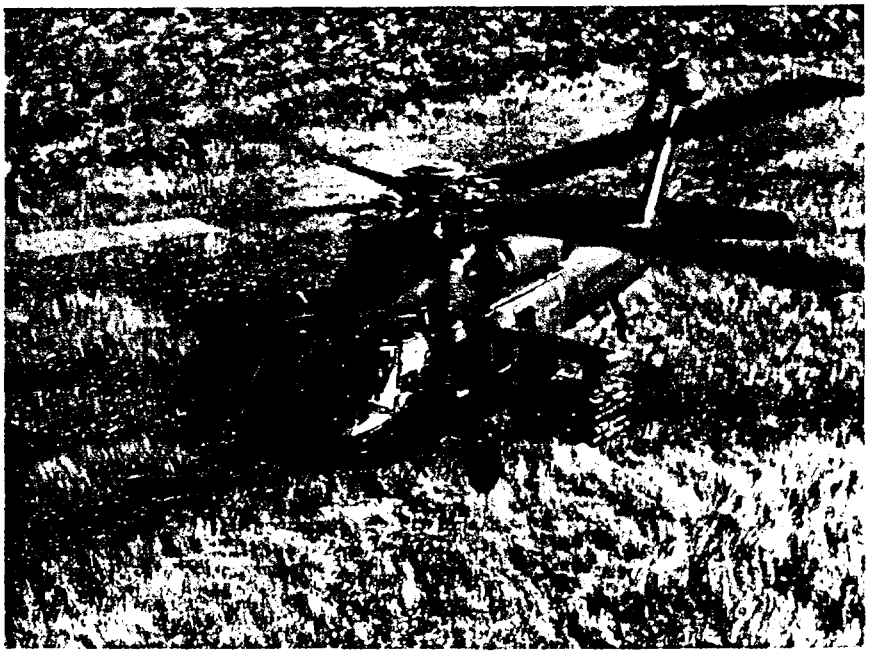
PAUL MANN/WASHINGTON

Politically, there is little chance the U.S. government's complex of national laboratories will receive funding for the major research and development effort they say is needed to combat nuclear, biological and chemical (NBC) terrorism and proliferation.

To the contrary, such R&D funding is declining despite the need for a sustained technology response to meet the rapidly evolving NBC threat, according to officials from Los Alamos National Laboratory in New Mexico.

But the Energy Dept.'s network of nuclear labs does enjoy one advantage in the counter-proliferation, counter-terrorist effort, according to the department's deputy secretary, Charles B. Curtis. "Fortunately, the Energy Dept.'s scientific and engineering talents [that] grew up out of the nuclear program also have direct application to other nonproliferation challenges—especially in the chemical and biological defense area."

Scientists say a U.S. Army UH-60 Black Hawk can be used to detect biological agents up to nearly 20 mi. away.



One example is a stand-off sensor called CALIOPE, for Chemical Analysis by Laser Interrogation of Proliferation Effluents. The laser interrogation technology involved is multipurpose. Because the presence of certain chemicals is indicative of nuclear production, CALIOPE could be used to detect nuclear materials as well as chemical signatures associated with chemical weapons. A joint Energy Dept./Defense Dept. demonstration of CALIOPE to identify, track and map chemical clouds in real time on the battlefield is planned for later this year. Eventually the system might be deployable on aircraft, or even on satellites.

Scientists at Los Alamos recently demonstrated a laser device on board an Army UH-60 Black Hawk helicopter that they say is capable of detecting clouds of biological warfare agents at distances of up to almost 20 mi. (*AW&ST* May 6, p. 13). The device was reported successful at differentiating among the demonstration biological agent, dust and vehicle emissions.

The demand for technologies like these is high in the military services. According to a recent Pentagon report, the number one counter-proliferation capability sought by the military's combatant commanders (CINCs) is better equipment to detect and characterize chemical and biological weapons threats, especially at long ranges.

Joshua Lederberg, a research geneticist and president-emeritus at the Rockefeller University, a scientific institution devoted to biomedical research, voices strong confidence about the possibilities of sensor development to defend against biological warfare. His optimism is based in part on the fact that some of the same diagnostic advances occurring in the biotechnology industry commercially can be applied to defense.

Nonetheless, specialists say detection is extremely difficult in all three categories of the NBC threat—nuclear/radiological, biological and chemical. Because a variety of materials can be used in nuclear or radiological weapons, the type and quantity of radiation produced are variable. The detectability of radiation from such materials declines rapidly with distance and with the amount of background material—including air—between weapons and a sensor, according to Gordon Oehler, director since 1992 of the U.S. intelligence community's Nonproliferation Center. Consequently, radiation sensors are unlikely to be effective as early warning devices if they are farther than some tens of feet from suspected materials.

The Space and Atmospheric Sciences division at Los Alamos monitors the atmosphere and near-Earth space for nuclear tests with satellite-borne particle and radio-frequency detectors. Techniques are in development to detect proliferation using neural networks, neutron spectrometry and krypton/xenon and tritium detectors. Some of these techniques also are being applied to ground-based detection and characterization of nuclear materials.

Satellite systems continue to be the crucial element for monitoring tests in the atmosphere and in space, according to Los Alamos, which says that follow-on systems to the existing GPS navigation and DSP military satellite systems will have to be developed to take advantage of modern sensor technology. (Both GPS and DSP satellites are fitted with nuclear detection systems.) In the tough fiscal climate, the focus is on small, less expensive satellite programs such as FORTE (Fast, On-orbit Recording of Transient Events). This satellite, scheduled for launch in March, 1997, is designed to improve U.S. detec-

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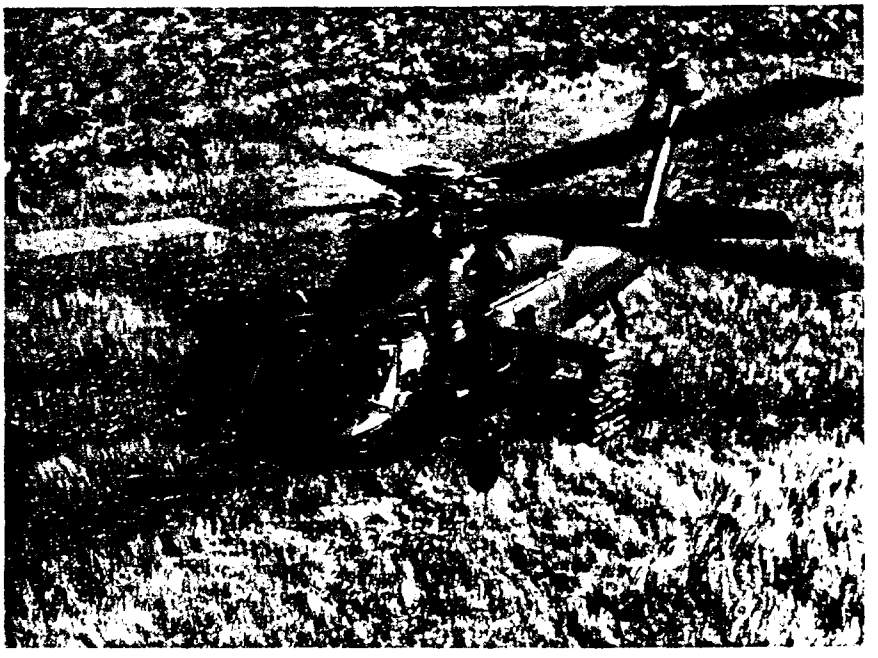

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tion of clandestine atmospheric nuclear tests by measuring the electromagnetic pulse they generate (*AW&ST* Nov. 27, 1995, p. 48).

Currently there are a number of "excellent efforts" devoted to exploiting laser absorption and fluorescence to allow the remote detection of either biological or chemical species, according to C. Paul Robinson, president and laboratory director of Sandia National Laboratories. These could be used for battlefield detection and warning, as well as wide-area monitoring. But Robinson cautions that these approaches will not become practical until they achieve much higher levels of specificity and fewer false alarms.

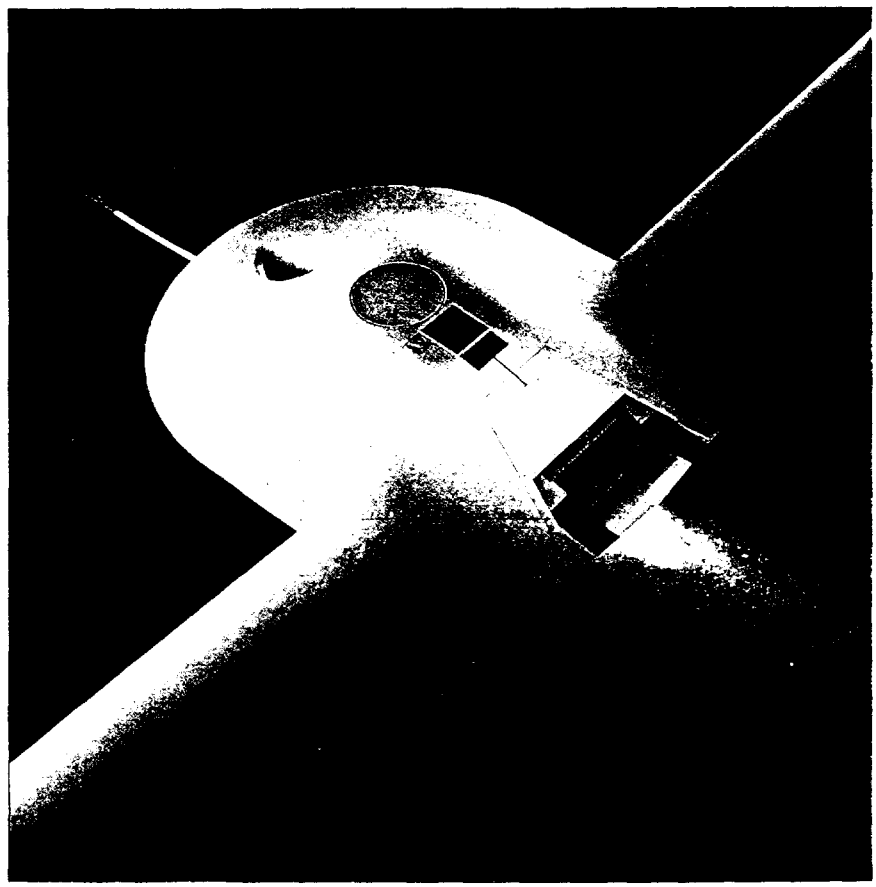
DEVELOPING INSTRUMENTS and platforms that could detect the full spectrum of potential biological or chemical agents is a daunting task. "I am unable to say, based on our present state of knowledge, whether it will someday prove possible or not," Robinson acknowledges. "We are certainly much closer to being able to develop sensors for chemical species than for biologicals."

Oehler says exceedingly few chemical sensors have been developed that have the broad suites of capabilities needed to address proliferation or terrorist use of NBC weapons. Detecting and characterizing chemical warfare activities are extremely difficult. "Production processes provide relatively weak chemical signatures, particularly at long ranges. In addition, very few emissions occur during transport. The worldwide chemical background complicates the search for at least some chemicals." In Oehler's opinion, point sensing—which requires physical contact with chemicals—and remote sensing—which relies on passive photon emissions or induced photon emissions—are promising intelligence collecting tools.

Point sensors that could provide nearly instantaneous detection of a wide spectrum of chemical species are in development at Sandia and at other labs. The basic technique uses a "lab on a chip." Semiconductor surfaces are coated with selective receptor materials that respond to specific chemical moieties or components. Using pattern recognition techniques, a single array of sensors can discriminate between a wide variety of inputs and provide near real-time data, according to Robinson.

Oehler says biological sensors with broad counter-proliferation capability are as lacking as chemical ones. Detecting and characterizing biological warfare activities are even more difficult than their chemical counterparts. Except in rare instances, biological agent-related materials occur in extremely low concentrations. Very few emissions occur while weapons are in transit. Dispersion is usually accomplished by aerosol; transport can be provided by crop duster, backpack sprayer, land and sea mines, even perfume atomizers. Extraordinarily tiny amounts of biological agents are lethal. One gram of anthrax produces one trillion spores, an amount equivalent to 100 million lethal doses. The disease causes lesions in the lungs.

One of the Pentagon's weaknesses is an historical lack of biological expertise. "Our current vulnerabilities to biological warfare are considerable," notes Under Secretary of the Navy Richard Danzig. They result not only from lack of attention and investment, but also from the history of how the Pentagon has assimilated technological change. World War 2 brought physicists and the military together in the Manhattan Project. The Cold War infused the military with experts from electronics, computers and telecommunications. No counterpart conflict integrated biologists into the Pentagon. "Today," says Danzig, "the number of biologists employed by the Defense Dept. is orders of magnitude less than the number of scientists and engineers employed in other areas."



Unmanned aerial vehicles may someday serve as important platforms for detecting biological and chemical warfare agents on the battlefield.

Development of biological defenses is difficult because genetic engineers can devise highly complex biological species to harness toxins, bacteria and viruses for weapons or terrorist use. In consequence, Sandia's Robinson believes, successful detection almost certainly is going to require the development of sensors so advanced they can differentiate between individual DNA components. "You've got to find a detector that will get within the DNA, and that's probably the greatest challenge on the table."

Oehler recalls that as recently as two years ago, the U.S. did not even have a technical roadmap for biological warfare sensors. More money would not have helped. So grave was the situation that in 1993, a Defense Science Board study warned that no federal agency had performed any serious planning about how to defend against a biological warfare at-

tack on U.S. cities or those of the nation's allies. "If such an attack should occur," the study predicted ominously, "the military establishment will be blamed for the failure in national defense, regardless of the purported mandate—and above all, we will blame ourselves."

Today, says Oehler, there are promising directions in technology, and more money would help. But as important as these sensor programs are, "they can't do it alone. Since the end of the Cold War, we don't have a very good track record of convincing decision makers to take actions based on technical sensor data alone." Those data can be used as tipoffs, but they must be supplemented with human intelligence and signals intelligence.

CURRENT METHODS USED in the field to search out chemical and biological materials are relatively slow in processing and readout time, and they require dedicated vehicles to transport them, Robinson says. If these systems could be miniaturized, or if electronic, direct readout systems mature, it might be possible to use unmanned aerial vehicles (UAVs), helicopters or other aircraft to transport the detectors. That would provide long-range surveillance for both NBC proliferation detection and the battlefield warning time urgently desired by the combatant commanders.

The Defense Dept. is investing about $3.8 billion this year in counter-proliferation efforts of all kinds. That amount includes $350 million for an integrated Chemical-Biological Defense (CBD) program, mandated by Congress and placed under the oversight of the assistant to the secretary of Defense for atomic energy. The same official supervises a joint program office for biological defense, established to guide important biological warfare acquisition programs, including battlefield detection and vaccine production.

Among the technologies being pursued under the CBD program are:

- Sensors for use by joint task forces and in mobile biological/chemical warfare reconnaissance to detect contamination areas.
- Development of systems capable of detecting multiple biological/chemical agents and of characterizing new agents.
- Collective protection systems, such as lightweight biological/chemical warfare protective shelters.
- Improved mask systems and advanced protective clothing.
- Better medical response, exploiting research in improved prophylaxes, antidotes, treatments, vaccines and casualty management systems.
- Development of modular decontamination systems.

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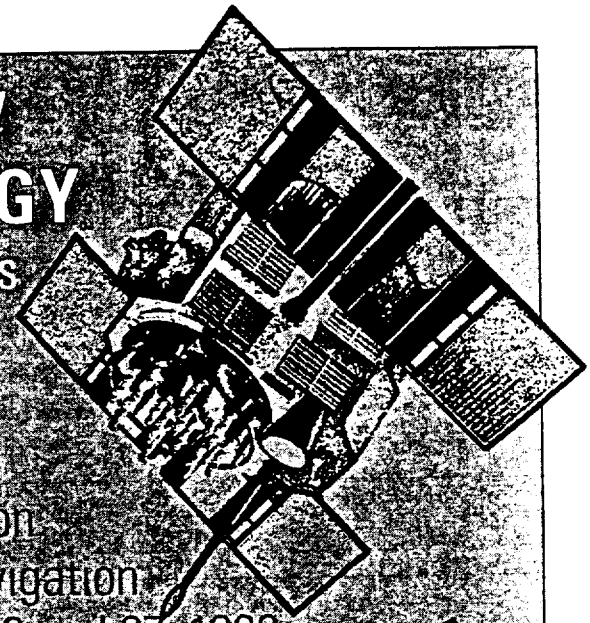

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