SPECIAL REPORT

Nuclear war: the safety paradox

In the second of a series of articles, **Geoff Brumfiel** looks at whether certain nuclear-weapons technology should be shared.

When a series of weapons tests announces a new member of the nuclear club, as in both Pakistan and India in May 1998, the natural response is to do everything possible to punish the proliferator and limit its future nuclear development. But some nuclear experts are drawn to the merits of the opposite course of action — supplying advice and technological aid. The argument is that if the world must have more nuclear weapons, it is in everyone's interests that they are safe ones.

To some, the idea of a safe nuclear weapon is the ultimate oxymoron. But the term has fairly clear meanings. A nuclear weapon is at least comparatively safe if it can go off only where and when the government that made it wants it to: not by accident, not on the say-so of a relatively junior officer in the field, and not after it has been stolen by terrorists (or anyone else).

Engineers and scientists in the established nuclear powers have spent decades developing safety mechanisms to ensure that weapons neither explode nor can be exploded if they are involved in accidents or mislaid. This is a real danger; when a B-52 bomber crashed into a tanker plane over Spain in 1966, three of its bombs crashed to earth and one was, for a while, lost at sea.

The details of such safety systems have remained largely classified. But growing instability in Pakistan has created interest in sharing this technology. An article in *The New York Times* in November claimed that US government experts had unsuccessfully pushed for sharing specific safeguard technology, whereas an earlier report by NBC News suggested that some sharing may have already occurred. And at a 5 January debate of Democratic presidential candidates in New Hampshire, Hillary Clinton said that she would advocate that Pakistan work with delegates from the United States and United Kingdom to develop a "fail-safe" for the weapons.

The wisdom of such transfers is hotly

debated among scientists and arms-control experts. "There seems to be a battle," says Michael Levi, a fellow at the Council on Foreign Relations in New York city, "between the lawyers and the technologists." On one side are those who believe such collaboration would undermine the Nuclear Non-Proliferation Treaty (NPT), the keystone of the world's effort to contain nuclear weapons. On the other are those claiming that the dissemination of such technology may ultimately prevent an act of terrorism or an unintended nuclear war.

Regardless of how dangerous a nuclear state may seem, nuclear weapons that are not under the leadership's control are worse, argues Jeffrey Lewis, director of non-proliferation at the New America Foundation, a Washington-based think-tank. "I think there's a need [for the safety technology], and I think it should be shared," he says.

Kill switch

There are two types of bomb safety device: those that stop a bomb from going off accidentally; and those that stop it from going off without proper authorization. Mechanisms for accident-proofing a bomb range from simple housekeeping (keep the explosive triggers entirely separate from the nuclear cores) to sophisticated design requirements such as 'one-point safety'. In a one-point-safe design, a nuclear explosion will not occur even if one of the various chemical explosive charges in the trigger goes off. This is quite a hard trick to master: before a 1992 voluntary test moratorium, the United States conducted 32 nuclear tests to establish one-point safety on each of its weapons.

Ensuring proper authorization is the role of what America calls a Permissive Action Link, or PAL. PALs are devices that keep the explosive systems of a bomb or warhead isolated from the outside world unless they are unlocked with a specific code: no code, no explosion. If the incorrect code is entered a set number of times, the PAL will disable the weapon, some-

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How safe are the nuclear weapons fielded by India (main picture) and Pakistan (inset)?

times with a small explosive charge. After that, the weapon will need extensive servicing before it can be returned to readiness.

Precisely what safety systems various nuclear states have is not open knowledge (the British television news programme *Newsnight* recently caused a stir when it revealed that Britain lacks a PAL system). But their limited system experience and short testing history make it almost certain that any safety systems fielded by new nuclear nations will not be as sophisticated as American ones, says Geoffrey Forden, a physicist and arms-control analyst at the Massachusetts Institute of Technology in Cambridge.

Pakistan, for example, is believed to keep its weapons safe through disassembly, keeping the nuclear cores and triggering explosives in separate locations. But little is known about how the separation is maintained, or how the assembly and arming processes are controlled.

Forden believes that without advanced safety and security systems, such weapons could be co-opted by terrorists or accidentally detonated. Particularly in the case of an accidental explosion at a military base, he argues, "the chances are that they'd think it was an attack",

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with the Pakistan Army who now teaches at the Naval Postgraduate School in Monterey, California.

Lewis suggests that one solution might be to avoid any active cooperation and simply declassify earlier generations of PAL technology as a resource for other countries. Another possibility would be to educate scientists on the general principles of PAL systems without providing technical details, says Sidney Drell, a physicist at the Stanford Linear Accelerator Center in

California who has examined nuclear-weapons issues.

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But such collaboration could still fall foul of the NPT (see *Nature* 451, 107; 2008). Article I of the treaty prohibits its assisting non-nuclear-weapons states in the manufacture of nuclear devices. Sharing PAL technology with others outside the NPT could easily be seen as contravening that prohibition, according to Wyn Bowen, head of research in the defence studies department at King's College London. "It's really against the spirit of the treaty," he says.

Joseph Cirincione, director for nuclear policy at the Center for American Progress, a Washington-based think-tank, concurs. "The solution is not to build bombs with better controls," he says, "but to eliminate the bombs we have."

Lewis counters that PALs would not alter the yield or military purpose of a weapon: "As long as you're not teaching them how to improve the function of their warhead, I don't see anything wrong with that."

For den sees further technologies as ripe for sharing — for example, a global network of early-warning satellites that could provide all nations with information about missile launches in not-quite-real time. Access to such a system would not give countries early warning of real attacks. But after an unexplained blast or accident, the system would allow the nation affected to see whether there had been any hostile launches that might explain the blast. Coyle is sceptical about whether countries could be persuaded to use such a system, however.

In many ways the real problem is that there are convincing arguments on both sides, Levi says. "You have two narrowly focused camps," he says. "But frankly, it's not the job of technologists or lawyers. We need a broader, more coherent approach." Ultimately, he argues, that approach can come only from politicians. ■

and would retaliate with nuclear force.

But sharing the details of PALs and other safety systems raises a range of problems. For one thing, sharing details about implementing the technology would also mean exchanging some information about the weapons for which it was developed. PALs must be placed at a critical point in the design, says Philip Coyle, a former designer now at the Center for Defense Information, a Washington-based defence think-tank. Sharing the location of PALs and the mechanism by which they work would be "on the edge of possibly revealing information about the design", Coyle says. There is thus the risk that new nuclear-weapons states could learn at least some details about US

nuclear weapons, and accordingly improve the capabilities of their own designs.

Another concern is that the safer the weapons become, the more comfortable a state such as Pakistan might feel about deploying them on the front line. This could negate, or even reverse, any advantages resulting from the improved inherent safety of the weapons themselves.

From the recipients' point of view, getting such technology means giving scientists from another country at least some details of bomb design. "No way will Pakistan be sharing with the United States or any other country any data or information about its nuclear programme," says Feroz Khan, a former brigadier general

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