The proliferation of deeply burrowed enemy bunkers could lead to new "mini-nukes" and even a change in U.S. first-strike policy. The technical and ethical barriers are huge.

by Andrew Koch

As the 1999 war in Yugoslavia Ended, doors to a bunker dug deep underneath Pristina Airfield opened, and nearly a dozen unharmed Serbian MiG-21 fighters emerged to retreat from the area. The United States had repeatedly tried to destroy this series of tunnels and caves with GBU-28s, 5,000-pound precision-guided "bunker busters" developed during the Gulf War. But the best those hulking bombs could do was seal off entryways by burrowing a few feet in before exploding from the impact. The MiGs, sheltered much farther down, were untouched.

Three years later, battling al Qaeda fighters hunkered down in mountain catacombs in the Tora Bora hills of Afghanistan, the U.S. military had come a long way. By then, the Pentagon's arsenal included the BLU-118/B, a powerful penetrating bomb with a thermobaric explosive that releases a series of sustained shock waves instead of the single spike typical of standard weapons.

The BLU-118 is perfect for attacking confined underground spaces like tunnels and caves. But like the GBU-28, the BLU-118 is virtually impotent against solid barriers. If the weapon hits rock, highly compressed dirt, or a blockade, it penetrates only about a half-dozen feet. The rock absorbs the thermobaric blows before they reach the underground redoubt. In Afghanistan,

numerous al Qaeda warriors and their weapons survived the Tora Bora onslaught unscathed, then snuck out of the area during a break in the bombing.

The Pentagon's limited success in taking out subterranean hideouts even with today's most powerful bunker busters has sent a shiver through the military. According to intelligence estimates, there are more than 10,000 underground havens in dozens of countries around the world. Many of them, in places like China, Iran, North Korea, and Russia, are sheltering aircraft and basic weaponry. But about 1,000 of these caves, tunnels, and labyrinths are considered highly strategic because they're suspected of harboring weapons of mass destruction, long-range missiles, or control centers to protect key leaders during an attack. The Defense Department is

certain, for instance, that Iraq is hiding chemical and biological weapons underneath its vast deserts and that North Korea has nuclear materials buried below its mountains. What's more, because of huge improvements in tunneling capabilities, thousands of additional deeply placed, unreachable bunkers are expected to be built in the next decade.

Faced with the prospect of "asymmetric" warfare against rogue powers or terrorist organizations with weapons of mass destruction tucked in their basements, the Pentagon has begun to consider the previously unthinkable: developing specially designed nuclear weapons for attacking buried caves and tunnels. These weapons would ideally do their damage while creating only limited nuclear fallout aboveground. Such a

move would represent the most significant rewriting of U.S. nuclear strategy in decades, because its intended purpose violates the two cornerstones of current policy: to use nuclear weapons only as a last resort and never to use them against nonnuclear nations.

Although the design of a fresh generation of nuclear weapons is in the very early stages, opponents have been quick to express their dismay. Their chief concern is that because nuclear bunker busters are being portrayed by some in the Pentagon—inaccurately, critics believe—as less dangerous than the traditional atomic arsenal, their development could relax nuclear taboos.

The result, opponents claim, might be a new arms race that repositions the world on a course toward nuclear Armageddon. "Nuclear earth-penetrating weapons lower the threshold for the use of nuclear arms," says David Wright, a researcher at MIT's security studies program. "If you're really serious about trying to stop countries from developing nuclear weapons, it's not a very good idea" (see interview).

But military planners insist the need for these weapons is so strong that it overwhelms any worries about the tactical repercussions, which, they say, are being overstated by critics anyway. As the number, depth, complexity, and perils of underground bunkers increase, the military argues, these new nuclear bombs are becoming indispensable. "Without having the ability to hold those targets at risk, we essentially provide sanctuary," says Assistant Secretary of Defense J.D. Crouch.

Two options for the new atomic arsenal are under consideration. Both are based on the idea that a nuclear weapon directed at the earth would unleash powerful shock waves that, like an earthquake, would rip apart even solid rock, shredding their way toward the most deeply shielded enemy. One choice is to upgrade an existing atomic bomb, such as the B61-11, the Pentagon's sole nuclear bunker buster. Developed quietly in the mid-1990s, the B61-11 was never viewed as a viable weapon because it performed poorly during earth- penetration trials. The Clinton Administration showed little interest in it and instead expressed support for international agreements that outlawed further development, testing, and deployment of nuclear arms. But the Bush White House has taken virtually the opposite stance: Its 2003 budget requested $45 million for a three-year feasibility study to explore the technical challenges of modifying a nuclear weapon into a useable bunker buster. At the time of this writing, the House had approved the funding, but the Senate rejected it. The matter will be hashed out in conference.

The other possible approach is more radical: to design an entirely new weapon called a mini-nuke, a bomb of 5 kilotons or less that can be driven like a spear into the ground. In some respects the mini-nuke is more desirable than a retrofitted larger weapon, proponents say, because they believe its low yield would release only a minuscule amount of radioactivity aboveground. While the idea has been around for several decades, the mini-nuke got a boost in the recently completed Nuclear Posture Review, the first Defense Department analysis of U.S. nuclear capabilities in 10 years. In it, the Pentagon said: "With a more effective earth penetrator, many buried targets could be attacked using a weapon with a much lower yield." The NPR's endorsement could be an important step toward convincing Congress to fund the design and development of the mini-nuke.

Meanwhile, if the weapon-modification feasibility study gets Congressional backing, it will be conducted by the National Nuclear Security Administration (NNSA), a Department of Energy agency, at the nation's three major nuclear weapons labs—Sandia, Los Alamos, and Lawrence Livermore. Much of the initial research will be focused on whether it is possible to turn the B61-11, which weighs only 1,200 pounds and in tests penetrated just 20 feet of rock and soil, into a gravity-driven, 5,000-pound bomb capable of cutting through as much as 80 feet of flat ground or mountainous terrain. The bomb would have to accomplish this feat without destroying the fragile electronics and other components responsible for delaying its more-than-300-kiloton nuclear explosion.

It's a critical requirement because the farther below the surface the explosion occurs, the more effectively the force of the tremendous blast of heat and ensuing shock waves is transferred into the ground. A nuclear weapon that explodes after penetrating 20 feet will have roughly the same destructive power against a deeply buried bunker as one that has 10 times the yield but is detonated aboveground.

A major challenge will be strengthening the weapon's casing and internal support structures to protect the warhead, says Paul Yarrington, a Sandia nuclear weapons scientist, because the warhead will not detonate if its explosives do not fire in perfect precision.

To counteract the intense frontal and lateral impact that increases as the weapon buries deeper, engineers are considering developing out of specially hardened metals a new casing and a sharper, reinforced nose—the part of the bomb that absorbs the most shock and heat. And they're investigating embedding into the casing alloy structures shaped like a honeycomb, a design that is already used in some bombs and that offers greater strength per pound than traditional bent metal shapes.

To accomplish such an extensive and crucial redesign, the engineers will have to accurately model, simulate, understand, and test the forces that act on the bomb while it is penetrating but before detonation. Of particular value, Yarrington says, will be supercomputer simulation programs developed over the past 30 years that produce three-dimensional models of how existing nuclear weapons operate. The simulations draw on

data from more than 1,000 nuclear tests the United States conducted before a self-imposed moratorium on testing was instituted in 1992. These include exact measurements taken by high-speed flash X-ray cameras of what occurs during a nuclear explosion and feedback from other sensors such as seismic monitors. By combining this information with the expected conditions during a nuclear bunker buster attack, engineers can model the effects of G-forces on enhanced earth-penetrating weapons.

To augment design work in the virtual world, engineers can perform physical tests on various metals and alloys that may be used for the casing, components, and subassemblies. For example, projectiles fired from a cannon into rock and steel targets would mimic the shock a warhead absorbs on impact with the ground. Data collected during these tests can then be fed back into a supercomputer to further refine the model. And when a prototype for the new casing is completed, dummy warheads with an inert substitute for the nuclear core can be dropped from aircraft against a mock target.

None of these experiments, of course, will involve actual nuclear explosions. The Bush Administration says it has no plans to try to overturn the congressionally mandated ban on such tests—which is what makes the development of a mini-nuke, the other possible approach to nuclear bunker busting, much more problematic. Repackaging an existing weapon can be accomplished with supercomputer design simulations, because existing data from prior research and development activities can be used as a foundation. But creating a low-yield earth-penetrating weapon, a fresh concept that has never been tried before, could require extensive fieldwork, including actual nuclear tests. Besides the testing moratorium, mini-nuke development is also blocked by the 1994 Defense Authorization Act, which outlaws R&D leading to the production of a low-yield nuclear weapon, defined as less than 5 kilotons.

Still, despite these impediments, the mini-nuke concept is gaining favor at the Pentagon. Military planners doubt that any president would risk the political backlash that could result from putting a big nuclear weapon like a retrofitted B61-11 into combat, but they're confident that a nuclear weapon of less than 5 kilotons—about one-quarter the size of the Fat Man dropped on Nagasaki and less than one-hundredth that of most weapons in the existing U.S. nuclear arsenal—would be more acceptable. That's because a 5-kiloton nuke would produce a limited amount of poisonous nuclear fallout capable of killing nearby civilians. According to the Nuclear Posture Review, this lower-yield nuke could achieve the same underground destruction as a modernized, high-yield bunker buster while producing one-twentieth to one-tenth the radioactive contamination aboveground. And because it would be more "usable," the military argument follows, a mini-nuke could be a "credible threat" that would prevent rogue nations and terrorists from developing underground hideouts and weapons of mass destruction, for fear of a U.S. nuclear strike.

"Having only high-yield weapons in effect self-deters the United States," says Stephen Younger, head of the Defense Threat Reduction Agency, which develops technologies and strategies for countering weapons of mass destruction, and a former director for nuclear weapons at Los Alamos. "An adversary would think that we would not use one

of our weapons because its destructive power was too great, whereas a lower-yield nuclear weapon would have greater deterrence value because politically it's more palatable," he argues.

To sidestep the ban on nuclear testing, one idea being floated for the mini-nuke's payload is to use the primary core of an existing two-stage thermonuclear device. This part of the weapon creates a fission explosion of 5 to 10 kilotons or less, making it a perfect option for the mini-nuke. What's more, mini-nuke proponents believe that by recycling primary cores they could circumvent the 1994 legislative ban on mini-nuke research and development, because they could argue that they're not building a weapon from scratch. "I wouldn't call it a new weapon," says former NNSA Administrator John Gordon. "But some others might."

Gordon was speaking about Sen. Jack Reed (D-R.I.), chairman of the Senate Armed Services Strategic Subcommittee, who headed the fight in the Senate against funding the NNSA's feasibility study. Reed says that instead of building mini-nukes or other nuclear earth penetrators, the United States should encourage nonproliferation by example: "There is no requirement for a new nuclear weapon, and the Bush Administration's decision to consider pursuing one leads us down a very dangerous and precipitous path." The competing defense authorization bill in the House not only backs the study, but also rescinds the 1994 ban prohibiting mini-nuke R&D.

No matter how the political disagreement is sorted out, mini-nuke critics take issue with the Pentagon's notion that it's technically feasible to create an atomic bomb that's large enough to destroy a bunker dug deep underground but that doesn't spew radiation into the atmosphere. "The dangerous idea is that you can do it with a clean bomb, and that is false," says Sidney Drell, a physicist at the Stanford Linear Accelerator Center and a longtime advisor to the U.S. government on nuclear weapon issues. Drell argues that it would be impossible to destroy a target buried more than 200 feet deep with a 1-kiloton bomb, yet anything larger would pack a blast too strong to be contained underground. Drell cites data from a 1962 nuclear test called Sedan at the Nevada Test Site that involved a 104-kiloton explosion 635 feet below ground. Despite the depth of the weapon, 12 million tons of radioactive earth and debris were propelled into the atmosphere. The crater it left was 1,280 feet in diameter and 320 feet deep.

"Sedan involved a weapon that was detonated at some depth with a relatively small yield, yet it produced a massive crater and spewed huge amounts of radioactivity," says Drell. "For bunker busters, reaching a depth of only 50 feet is still a challenge. So for the weapon to have a large enough yield to destroy a deeply buried target, imagine the damage that would result aboveground."

Although the wreckage left behind by nuclear experiments like Sedan is hard to erase from memory, there has been a definite shift in perspective recently, encouraged by some at the Pentagon who are hoping to diminish the big picture fear of nuclear attacks and replace it with the notion that a U.S. first strike may actually be necessary in today's geopolitical environment. Illustrative of this new attitude are views that would have been considered political suicide not long ago, such as those of Rep. Curt Weldon (R-Pa.), who

calls for "untying our hands from the outdated laws that stifle research and development in nuclear bunker-busting technology." Only that change in policy, Weldon says, will allow the United States to "focus on preventing a chemical or biological attack, rather than responding to one."

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