# The Science of the Silver Bullet

Depleted uranium has been hailed as the military¿s new silver bullet and condemned as Kosovo¿s Agent Orange

By Harald Franzen

Image: ERNST SCHMID/CHRISTOPH WIRZ

**SILVER BULLET** made from depleted uranium can pierce even the heaviest armor. Uranium shells burn away at the edges upon impact¿a "self-sharpening" that helps them bore into armor.

Used as ammunition, it penetrates the thick steel encasing enemy tanks; used as armor, it protects troops against attack. And when it was used in the Gulf War and later during the Allied bombing of Yugoslavia and Kosovo, depleted uranium (DU) was hailed as the new silver bullet that would solve most of the military¿s problems.

After the end of Operation Allied Force, however, several Italian soldiers were diagnosed with leukemia. Politicians and the media soon forged a link between the disease and depleted uranium use. They further drew a parallel with Gulf War Syndrome¿and in no time, depleted uranium became the Agent Orange of the Balkan conflict.

Despite the recent attention, depleted uranium is not all that new. The military has experimented with it since the 1970s. Military interest in the heavy metal is twofold: For one thing, uranium is almost twice as dense as lead, and thus packs a lot of punch as ammunition. Like its slightly denser cousin, tungsten, uranium can penetrate most heavy armor. But whereas tungsten projectiles become rounded at the tip upon impact, uranium shells burn away at the edges. This "self-sharpening" helps them bore into armor.

Also attractive to the military is depleted uranium's abundance. Depleted uranium is a by-product of the process by which uranium 235¿the most radioactive and most useful form of uranium¿is isolated from natural, mined ores (for more information, see the side bar). In 1998 the U.S. Department of Energy had about 500,000 metric tons of depleted uranium in storage.

Depleted uranium armor-piercing incendiary (API) munition comes in two main forms. One is fired from the suitably nicknamed "Tank Buster" A-10 Thunderbolt aircraft; the other shoots from M1 Abrams tanks, which are also enforced with DU armor. Both types of API munitions¿a total of 300 tons¿were used during the Gulf War. But only the A-10 kind was used during Operation Allied Force in Yugoslavia.

According to a statement by NATO Secretary-General Lord Robertson, some 31,000 rounds of DU ammunition were used throughout Kosovo during the 11 weeks of Operation Allied Force. Each round of A-10 DU ammunition contains a 300-gram DU penetrator slug, which brings the total amount of depleted uranium dropped during the conflict to a little less than 10 metric tons.

**Radioactive and Toxic**

Image: ERNST SCHMID/CHRISTOPH WIRZ

**DU AMMUNITION** can easily destroy an armored vehicle such as the American M1 A1 above, which was accidentally hit by friendly fire.

The question now is whether the metal that lies scattered over a wide area of the Balkans presents a health threat to soldiers and civilians. "There are clearly two issues" with DU, explains David Brenner of Columbia University's School of Public Health, "the radiation and the toxicological issue." Indeed, not only is depleted uranium potentially dangerous because of its radioactivity, it is also a strong toxin. "If there are effects, it would seem to me that the radiation effects would be the smaller of the two," adds Brenner, a specialist in the biological effects of radiation.

In fact, compared to other materials, uranium and depleted uranium are not terribly radioactive (see the side bar). The latter is used to actually shield radiation from fuel rods in nuclear power plants. But that's not to say that they couldn't have some deleterious health effects. As uranium and its daughter products decay, they emit alpha-, beta- and gamma-radiation¿all of which behave differently within the human body. Gamma-radiation can reach far into the body, but releases its energy gradually. As a result, it has little impact on any one part or organ. Alpha- and beta-radiation, on the other hand, are more hazardous because they have a short range and release all their energy within a small area.

"The so-called RBE, the relative biological effectiveness, for alpha particles is about 20 times higher than that of x-rays or gamma rays," says Tom Hei, also of Columbia University, who studies radiation and cancer. Brenner agrees that alpha-radiation is the biggest concern, but adds that its short range also makes it less harmful in some ways: "The alpha particles have to reach sensitive cells to be of any relevance. The distance they can travel in tissue or water or something like that is in tens of microns." In other words, if a person is exposed to alpha-radiation from the outside of the body¿from standing next to a pile of uranium, for example¿the alpha-radiation won't penetrate the skin, if it reaches the skin at all.

So what is important, then, is not so much the amount of radiation involved, but how much enters the body. The relevant unit for the impact of radiation on tissue is the Sievert (Sv), defined as the amount of energy given off in one kilogram of tissue. Another unit to describe the same thing is the Rem (100 Rem is equivalent to 1 Sv).

In a normal setting, a person is exposed to between one and three millisieverts (1Sv = 1,000 mSv) per year. If you were to stand about three feet from 1 kilogram of DU for one year¿the equivalent of about three A-10 shells¿you would be exposed to about one millisievert per year. But the tissues exposed would most likely be skin or fat¿neither of which are among the sensitive cells Brenner mentions above. Indeed, to do real damage, the radiation would have to reach tissue such as bone marrow.

Theoretically that could happen if a soldier got fragments of uranium embedded in his or her body through injury in combat. During Operation Desert Storm, about 30 soldiers were hurt when their tank was hit by "friendly fire" that contained depleted uranium. As a result of the incident, several soldiers were left with DU shrapnel embedded in their bodies. "Then perhaps the DU is right next to bone marrow, for example, so the alpha particles would have enough range to damage the blood cells," Brenner says. The soldiers' health is being closely monitored, but so far there is no evidence of any ill effects.

**Ingested or Inhaled?**

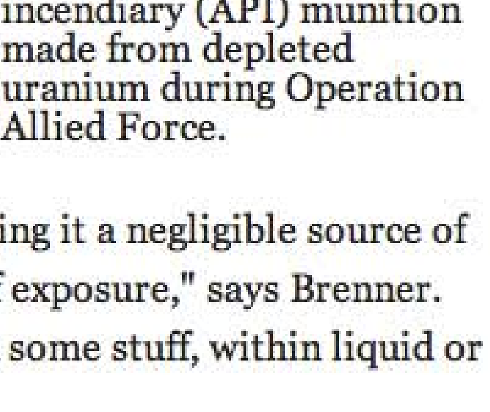

Image: USAF

**A-10 THUNDERBOLTS,** such as the one above, carried armor-piercing incendiary (API) munition made from depleted uranium during Operation Allied Force.

Of course, there are other ways that depleted uranium can enter the body. When DU projectiles hit a target, they partly burn up, creating uranium dust particles, or aerosols. Unlike southern Iraq, Kosovo and Yugoslavia are agricultural regions, and some observers have raised the concern that uranium dust particles might enter the food chain through crops.

According to the AC-Laboratorium Spiez, an independent laboratory that tests soil samples for the United Nations and other organizations, only about 17 percent of the DU particles found after a DU explosion are easily soluble, and might thus find their way into foods. Of those, only 2 to 5 percent are actually taken into the blood stream through the digestive system, making it a negligible source of radiation. "That would be the smallest possible source of exposure," says Brenner. "Because, again, the alpha particles would then be within some stuff, within liquid or whatever and it wouldn¿t have enough range to get out."

Apart from ingesting the aerosols, they can also be inhaled¿a potentially more harmful path. "When you inhale some of these particles¿for instance, in the case of radon, which is a decay product of uranium¿these particles give off alpha-radiation, which could cause lung cancer," Hei says. The correlation between radon and an increased risk of lung cancer was first discovered in uranium miners, who inhaled large quantities. As many as 75 percent of them got lung cancer. Radon gas also rises naturally from the soil, especially in regions with high granite concentrations such as the New York/New Jersey area.

"It depends on how much [exposure] we are talking about here," Brenner says. "I think you would probably get a bigger exposure just from being in your house than from almost any conceivable DU exposure." Similarly, he does not believe that temporary exposure to the radioactive aerosols will do damage. "If you just inhale radon gas, for example, the alpha particles would be in the air in your lung and would have no range to get to any significant, sensitive cells."

Of importance is where exposure to the aerosols occurs. "In an outdoor setting, like in a war or something, the concentrations would be very low," Brenner says. The worst-case scenario might be for the crew of a tank hit with DU ammunition. According to a study by the AC-Laboratorium Spiez, those soldiers could inhale up to 50 milligrams of uranium aerosol. Still, only about 25 percent of the particles with a diameter less than 10 microns would be deposited in the lungs. And as mentioned above, only a small percentage of them would be easily soluble. The rest would be incorporated into the mucus in the lungs, and coughed or sneezed back out in less than an hour.

**Poisonous Legacy?**

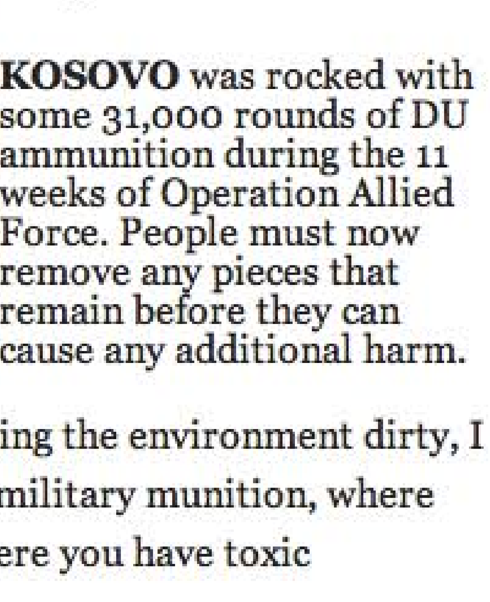


Image: NATO

**KOSOVO** was rocked with some 31,000 rounds of DU ammunition during the 11 weeks of Operation Allied Force. People must now remove any pieces that remain before they can cause any additional harm.

To be certain, inhaling or ingesting uranium aerosols delivers some additional radiation to the body, but the real health threat may have nothing to do with radioactivity. "Uranium is a toxin that effects the kidneys," toxicologist Bruce Kelman says. "Once you get the uranium into biological fluids, it mostly goes to the liver and kidneys. It breaks down the tubules in the kidneys that allow you to filter the urine out."

It is difficult to say how little depleted uranium it might take to make a person sick, Kelman says, because it depends on its physical form and whether it was inhaled, ingested or shot into the body. "The U.S. EPA [Environmental Protection Agency] determined that the most appropriate oral measure to use was a study in rabbits indicating that the lowest level at which there was an adverse effect observed was 2.8 mg/kg/day"¿that is, milligrams per kilogram of body mass per day. To put that into perspective, Kelman observes, "in terms of making the environment dirty, I don't think it makes it any dirtier than any other kind of military munition, where you have lead scattered throughout the environment, where you have toxic components of explosives that are left over."

So thus far, the threat seems negligible, but a certain amount of caution is warranted. "There is a general known lag period between radiation exposure and when a cancer is going to occur, if it's going to occur," Brenner says. "And it's on the order of 20 years or so. So you wouldn't expect to see radiation-related cancers from, say, Kosovo now. That would be against everything we know about how radiation causes cancer." There are two exceptions to that rule: thyroid disorders and leukemia. "Radiation-induced leukemia occurs generally in the first five years."

Most of the controversy over Kosovo has, in fact, focused on leukemia. After several NATO soldiers who served in Kosovo were diagnosed, the World Health Organization investigated whether the number of leukemia cases in Kosovo had risen during the last few years. They came to the conclusion that it had not. But this past November, the United Nations Environmental Program followed up, sending a team of experts to Kosovo to take soil and water samples in 11 locations. "At eight sites the team found either slightly higher amounts of beta-radiation immediately at or around the holes left by DU ammunition, or pieces and remnants of ammunition," Pekka Haavisto, former Finnish environment minister and leader of the UNEP¿s Balkan Task Force team, said in a statement on January 11.

A later analysis concluded that some of the depleted uranium used during the war contained traces of plutonium and uranium 236¿neither of which occur naturally, but are created during nuclear fission. This discovery made the origins of the DU a hot political issue and raised additional health concerns because both materials are far more radioactive than regular DU. As it turned out, though, the traces of U236 were so small that they did not change the radioactivity of the depleted uranium; so too, the plutonium content varied from a negligible 0.8 to 12.87 becquerel per kilogram.

Although depleted uranium may not pose an immediate threat, because it is both radioactive and toxic, some action is warranted. Klaus Toepfer, executive director of the UNEP, sums up the recommendations made by the Balkans Task Force in 1999: "Highest priority should be given to finding pieces of depleted uranium and heavily contaminated surfaces. Measures should be taken for the secure storage of any contaminated material recovered.