Researchers seek ways to beef up military armor

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It was a simple act, really, one that Ledjan Qato performed dozens of times in the corner of a spacious engineering lab at Villanova University.

Again and again, he lifted a 14.5-pound weight more than 4 feet in the air and dropped it - BANG! - on a series of metal tubes. Again and again, they were crushed by the impact.

Some, however, were crushed less than others, and therein lay the rudimentary beginnings of a project to protect U.S. soldiers in Iraq and Afghanistan.

Qato and his colleagues are working to devise better armor for the underbodies and sides of Humvees and other military vehicles, as are numerous other teams in academia and the private sector.

The military has made improvements to its vehicles, but insurgents are still exacting a deadly toll with improvised explosive devices (IEDs), according to data from the Joint IED Defeat Organization, an arm of the Pentagon.

From May through October, the most recent six-month period available, there were 512 "effective" attacks against vehicles manned by the United States and its allies in Afghanistan, meaning attacks that resulted in at least one casualty.

A layer of metal tubes is just one of several ideas the Villanova

engineers have for making a kind of protective crumple zone on vehicle exteriors. They are testing it not just by crushing the tubes, but by running sophisticated computer models and detonating actual explosives.

Fittingly, the team boasts a partner who is good at blowing stuff up. That's Jamie Hyneman, the beret-wearing co-host of the Discovery Channel show "MythBusters," who is friends with Villanova assistant professor Edmond J. Dougherty. The two worked together previously on other projects, including the Wavecam, an aerial robotic camera used for sporting events at several universities.

The vehicle-armor project, in partnership with a company that Dougherty founded called Ablaze Development Corp., initially was funded with $70,000 from the Office of Naval Research. It is one of several efforts under way in a field that still has room for improvement years after the start of conflicts in Iraq and Afghanistan.

In Maryland, for example, a company called Hardwire L.L.C. has developed an experimental blast "chimney" that would run up through the body of a Humvee, allowing some of the explosive power to be funneled away from soldiers.

Currently, the bottoms and sides of military vehicles are protected by thick steel plates. While these may remain relatively sound after a hit from a roadside bomb, they can nevertheless allow a fair amount of force to be transmitted inside, said Villanova mechanical engineering professor Gerard F. Jones.

With the current steel plates, he said, "The personnel are less likely to get hit by shrapnel, but the energy is still coming through and causing broken bones."

It's a little bit like how a person wearing a sturdy pair of pants can fall

and get a bad scrape on a knee, even if the pants remain intact.

The goal of the Villanova project is to devise a layer of protection that would absorb or redirect some of the energy. One possibility is a layer of metal tubes such as the ones Qato tested, sandwiched by thin metal plates on either side.

Hyneman built some initial prototypes with various shapes and configurations of hollow tubes, which he tested at a county bomb-disposal range in California. The Villanova engineers then added the concept of filling tubes with fluid, like automotive shock absorbers.

The Villanova tubes have thinner capillary tubes sticking out one end, so that when a tube is crushed, some of the energy is absorbed by the fluid as it is forced through the capillary.

"Only a portion of the energy goes into damaging the tube itself," said Sridhar Santhanam, a Villanova professor of mechanical engineering.

Qato, a graduate student who recently left the school for a defense industry job, crushed tubes that had been filled with various substances, including oil, water and a substance called shear thickening fluid. That material becomes more viscous in response to a big impact - like the phenomenon in a common elementary school experiment in which you jab your finger into a mixture of cornstarch and water and it feels solid.

(The oil, meanwhile, was just a test substance. They would not use that on a vehicle because of flammability.)

Dropping the weight was a rough way to simulate an explosion. The weight crushes a tube in a matter of three to four milliseconds, whereas a real explosion lasts one-tenth as long. Still, measurements of the forces acting on the tubes were useful in developing a computer model of a

blast, Qato said.

After criticism that Humvees were vulnerable to roadside bombs, the Pentagon purchased thousands of Mine Resistant Ambush Protected vehicles - MRAPs - which have V-shaped hulls to deflect blasts. Later came the M-ATVs - nimbler all-terrain MRAPs that are better suited to the steep, mountainous roads of Afghanistan.

Villanova's concept is intended for use with any of these vehicles. Several other university-private sector partnerships received Office of Naval Research funds for similar lightweight, energy-absorbing prototypes.

Pentagon officials declined to comment on any efforts to improve vehicle armor.

But Loren Thompson, a military analyst at the Lexington Institute, a think tank in Arlington, Va., said such research would be welcome.

"It sounds pretty promising because we're going through a period of fiscal austerity," Thompson said when told of the Villanova project. "Any research that can solve this problem inexpensively is going to be valued highly."

So far, tests have showed that tubes filled with the thickening fluid fare best, Santhanam said. In a computer simulation of an explosion, such tubes absorbed 30 percent more energy than the empty variety.

The next step is to make test panels with the fluid-filled tubes and subject them to real explosives, to compare their performance to solid steel panels, Santhanam said. The key will be to make them as light as possible without sacrificing protection.

"It's a tricky trade-off," he said.

In addition to the tubes, the engineers may try to build panels that contain a light, porous material called aluminum foam - what Santhanam likened to a "metal sponge."

If they can pull it off, they hope to make it from the lab to the battlefield.