U.S. military embraces robots with greater autonomy

David Alexander, Reuters

(Reuters) - The unattended steering wheel on the 15-ton military truck jerked sharply back and forth as the vehicle's huge tires bounced down a rain-scarred ravine through mounds of mine rubble on a rugged hillside near Pittsburgh.

Oshkosh Corp engineer Noah Zych, perched in the driver's seat, kept his hands in his lap and away from the gyrating wheel as the vehicle reached the bottom of the slope and slammed into a puddle, coating the windshield in a blinding sheet of mud.

As the truck growled up another rise and started back down again, Zych reached up and flicked a wiper switch to brush away the slurry, then put his hands back in his lap.

"We haven't automated those yet," he explained, referring to the windshield wipers, as the robotic truck reached the bottom of the hill and executed a perfect hairpin turn.

Ten years of war in Afghanistan [1] and Iraq have put a spotlight on the growing use of unmanned systems in the skies over the battlefield, from the high-flying Global Hawk to the lethal Predator aircraft and the hand-launched Raven.

But on the ground, thousands of small, remotely operated robots also have proven their value in dealing with roadside bombs, a lethal threat to U.S. troops in both wars. Of more than 6,000 robots deployed, about 750 have been destroyed in action, saving at least that many human lives, the Pentagon's Robotics Systems Joint Program Office estimates.

Only now is robotics research nearing the stage that the military may soon be able to deploy large ground vehicles capable of performing tasks on their own with little human involvement. The results, among other things, could be more saved lives, less wear and tear on the troops, and reduced fuel consumption.

Full autonomy, engineers say, is still years away.

"The ground domain is much, much tougher than the air domain because it's so dynamic," said Myron Mills, who has worked on both aerial and ground robotic systems and now manages an autonomous vehicle program for Maryland-headquartered Lockheed Martin Corp.

Mills said autonomous ground systems face a series of challenges such as dust, fog and debris - as well as avoiding civilians and troops. A path may be passable one moment and littered with obstacles a half hour later due to battle damage.

"It's just a very, very tough and chaotic environment," Mills said. "The hardest thing to deal with has been figuring out how to make the system usable for the soldiers and be able to cope with the chaotic environment."

Enough progress has been made that Lockheed's Squad Mission Support System, a 5,000-pound (2,268 kg) vehicle designed to carry backpacks and other gear for overloaded foot soldiers, is now being tested in Afghanistan.

Wisconsin-based Oshkosh's unmanned vehicle system, which would allow one person to control several heavy cargo trucks, has been assessed by U.S. Marine Corps drivers in the United States and is in the final stages of concept development.

A four-legged walking robot designed to carry loads for combat foot patrols - the Legged Squad Support System, or LS3 - is due to undergo testing and assessment with troops toward the end of the year, developers at Massachusetts-based Boston Dynamics said.

The potential payoffs could be huge. Robotic systems could "radically alter the balance" among the variables that are driving the high cost of combat vehicles, according to a report for the Pentagon last year by the nonprofit Rand Corporation.

Taking drivers out of the trucks would reduce the need for thick armor plating that increases weight, boosts the need for ever more powerful engines and ratchets up fuel consumption in places like Afghanistan, where the cost of delivering petroleum can run as high as $400 per gallon, the Rand report said.

Advances are significant enough that military officials say they are committed to continued development of robotic systems despite a budget environment that calls for reducing projected defense spending by at least $487 billion over the next decade.

"We've had some ... very good success with unmanned systems. And robotics across the force is going to be more and more evident," Marine Corps Lieutenant General Richard Mills told reporters recently.

CONQUERING THE HURDLES

Before robots can take on new and expanded roles, engineers must conquer the hurdles that prevent them from operating more autonomously. Rob Maline, enterprise director for the military's Joint Ground Robotics program, calls that a "major technical challenge."

Most of the 6,000 robots fielded so far, including 2,100 now in Afghanistan, have been small, remotely operated systems driven by someone watching a video feed from cameras on the vehicle.

To take on greater autonomy, robotic systems need more than video cameras. They need sensors that can give them an accurate view of the world, and the capacity to

interpret that input so they can respond appropriately to the situation.

The perception system on Oshkosh's unmanned cargo truck begins with a three-dimensional LIDAR, or light detection and ranging system, a technology similar to radar.

While radar uses radio waves or microwaves, the LIDAR uses lasers, which produce a more tightly focused wave that can deliver images with sharper resolution. Fused with that are short- and long-range radars. A global positioning system, coupled with detailed maps of the route, helps the system navigate and keep itself on the road.

A half a dozen video cameras, including an infrared camera for "seeing" in the dark, help it build an image of the world around it so it can drive without GPS assistance if necessary, or enable a remote operator to take over and drive the vehicle from a nearby truck if the autonomous system runs into trouble.

"Those sensors feed into the perception systems, which essentially process all that into a map which allows the vehicle to actually drive based on all that information," Zych said.

Even with all the sensors, processing the input and dealing with it appropriately can be tough for the software algorithms, the step-by-step computer instructions that drive the system.

Laser beams can bounce back to the sensors from fog, dust, smoke and foliage, making it seem the vehicle is facing an obstacle. They can reflect off water in a puddle and bounce into space, never returning to the sensor and making it appear as if the truck is facing an infinitely deep hole.

"I think the layperson person thinks ... you put a camera on a computer and a computer can understand that scene. And that's definitely far from the truth," said John Beck, the Oshkosh chief engineer for unmanned systems. "One of the largest challenges is really getting the vehicle or the robot to understand its environment and be able to deal with it."

To ensure the vehicle makes the correct driving decisions, the Oshkosh team continuously refines the algorithms to improve the way the system interprets what it is seeing and responds more quickly and efficiently.

"When you've got a 15-ton truck, potentially with a 7-ton payload in the back, moving at 35 mph, an extra 20 milliseconds, 40 milliseconds of processing time ... means you may not be able to drive that fast because you wouldn't be able to stop in time," Zych said.

Feedback from the Marine Corps drivers who tested the vehicle last year has helped to improve performance.

"One of the largest complaints they had was about the way it drove," said Captain

Warren Watts, the Marine Corps liaison with the project. "It had a big stop-and-go jerkiness reaction."

The software was tweaked in response to the criticism to let the vehicle anticipate stopping and starting, enabling it to brake and accelerate more smoothly so it would "drive like Marines drive and not like a robot drives," Watts said.

TESTING IN COMBAT

One system with significant autonomous features is already being tested in Afghanistan. The Squad Mobile Support System - a rugged, six-wheeled vehicle about the size of a golf cart - is billed by Lockheed Martin as the largest autonomous ground vehicle ever deployed with ground troops.

The SMSS, whose mission is to lighten the load of overburdened foot soldiers, is capable of carrying some 1,200 pounds (544 kg) of gear.

It can be driven, or allowed to drive by itself using points on a route map, or even programmed to follow behind a soldier at a fixed distance, regardless whether the person is walking or running - an experience Mills said can be a bit unnerving.

"It's a little like having a 5,000 pound (2,268 kg) dog following you around wherever you go. If you speed up and start running, it speeds up and stays right with you. If you suddenly come to a halt, it suddenly comes to a halt behind you," he said.

Like other autonomous systems, the SMSS can run into difficulties that force it to stop and call for human help. That means it needs supervision and oversight.

Mills calls it "supervised autonomy," saying: "It doesn't require constant attention and fiddling and correction, but there are times when you do have to intervene."

That's not likely to change soon, Maline said. Fully autonomous robots are still years away, and until that goal is reached, there will have to be humans in the loop.

Beck and Mills said full autonomy would likely be an evolutionary process, both for military systems as well as the automotive industry. Driverless features are likely to be added as they are shown to contribute to highway safety or efficiency, eventually progressing toward full autonomy, they said.

"We're taking baby steps," Beck said, pointing to features like automatic braking systems and stability control on commercial vehicles.

"I think there's going to need to be a human in the loop for quite some time before we can basically black out the windshield and be texting as we're going down the highway," he said.

(Editing by Warren Strobel [2] and Will Dunham [3])

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