Picture credit: Endeavor Robotics

ROBOT ARMS RACE

Timothy Compston *investigates the changing capabilities of EOD robots and their manipulator arms*

EOD robots have changed beyond all recognition since they were first deployed in environments like Northern Ireland during 'the troubles'. As vendors drive ahead with plans to integrate increasingly sophisticated manipulator arms into their EOD robots and to produce more compact solutions, we look at the opportunities this creates when dealing with unexploded ordnance (UXO).

Across the Atlantic, Paul Bosscher chief engineer for Robotic Systems at US vendor Harris Corporation – whose new T7 robotic system is going into service with the British Army – underlines the value that more degrees of freedom can unlock for EOD tasks: "Adding degrees of freedom, extra joints, to a robot arm can give more dexterity." For Bosscher the high-level goal is to make arms more human-like from a dexterity and a precision standpoint: "Ideally, you want them even stronger than a human arm and able to do things like opening up doors, opening up a car glove box and unzipping a bag, all the manipulation-intensive tasks that are required to access, inspect, and ultimately defeat a threat." Of course, he acknowledges that a balance needs to be struck with regards to degrees of freedom: "In general with more complexity there are more potential failure points."

The PackBot was widely used in Afghanistan and is light enough to be carried around by a soldier

DRIVE FOR DEXTERITY

Along with the drive for dexterity Bosscher says that one of the challenges for EOD missions is that part of the job of the manipulator is to deliver EOD disruptors, put them on target and to use them. Continuing down this track, he stresses that the more powerful the tool – like a disruptor – the more things you can do with that tool, but conversely the harder it is to handle: "The UK, as an example, uses very high-power disruptors. The most powerful has about the same kick – recoil – as firing a 50 cal gun. It is a very big bang and something that if you take one of these and strap it to an arm that is now fairly complex – because it has lots of joints – the potential for damaging parts is much higher."

So, what is the answer to this dilemma? One approach might be to try to make an exceptionally strong manipulator arm for robotic arms, Bosscher explains

> **HAPTIC FEEDBACK GIVES THE OPERATOR THE ABILITY TO 'FEEL' WHAT THEY ARE PICKING UP**

that a 'compounding effect' comes into play that tends to work against engineers: "If you make the joint at the wrist thicker and stronger it makes it heavier, now the joint before that one has to be stronger to lift up the heavier joint. To get 10 percent more strength you may have made your robot arm 30 percent heavier."

Rather than go and build an unwieldy 'tree trunk' of an arm, Bosscher reveals that Harris has instead developed a robot arm attachment for the T7. The upshot of this is that the problem has been addressed partly by making a very robust arm, but also partly by creating a payload for the robot: "It is what we call our disruptor rack – or you might call a weapons block – but is for mounting disruptors and it has a built-in ability to absorb large shocks," he concludes.

Touching on other innovations coming into play to make life easier for operators and to protect the manipulator arms, Bosscher says that Harris now even has smart software algorithms running on the T7 robot that can automatically manage collision prevention: "Operators can feel free to move the arm however they want without having to worry that they are going to bash parts of it together and have to scrub the mission."

Another good example of the direction of travel for today's EOD robots and their manipulator arms, is the aptly named Reacher, a solution now coming down the track for the Irish Defence Forces that features a sliding and rotating (220°) turret, a low-profile 7° of freedom arm and a powered payload bay. Padraig O'Connor, the managing director of Reamda Ltd, emphasises the importance of taking a holistic approach where the survivability of a manipulator arm like the one on the Reacher is concerned: "It should never just be about the arm. Everything on the machine has to complement everything else." A case in point, he says, are the Reacher's high-powered traction drives: "There are six wheels that move the Reacher on the ground with a total pulling force of 1,200 Newton Metres (Nm). If the machine can do that it means that the arm has to survive that as well."

Crucially, O'Connor emphasises that the whole idea behind the Reacher is that there should be no place on the perimeter of the machine that the claw cannot get to: "That is purely down to the sliding turret. The turret in our machine is different because with its metre, metre-and-a-half, of travel it allows you good access when space is restricted because you can shift the turret to a different position."

Alongside this, according to O'Connor, keeping the Reacher's manipulator arm free of protrusions is a sensible move as it stops wires and cables being snagged and damaged if EOD operators should decide to send the arm through a tight space like a car window. The decision to build Reacher with a motorised cargo bay also makes sense, he says, to protect valuable equipment in transit as otherwise items may have to be strapped to the outside of the robot or carried by the manipulator's claw: "If the machine crosses very rough terrain you don't want it dropping a fragile X-ray panel."

SIZE MATTERS

Changing gear to smaller robots, one vendor that continues to lead the charge is US-based Endeavor Robotics. Offering an inside track on developments, Sean Bielat, the vendor's ceo, rewinds to the origins of the PackBot: "That was kind of our first defence success. It went into Ground Zero after 9/11 and then it went into Afghanistan and was used for cave clearing and exploration and then it was used in Iraq for counter IED and proliferated from there." Bielat adds that the PackBot was originally part of what was called the Man Transportable Systems Programme: "The idea was exactly that to have a robot that could be easily carried and moved around by a dismounted soldier. The PackBot is about 60 pounds or just a little under. It is definitely light enough so that a single person can carry it, and move it around, but it is not lightweight you wouldn't want to carry it around all day."

By the mid-2000s, Bielat says that things came down in scale with the SUGV – Small Unmanned Ground Vehicle – of which there are now more than 1,200 in the field: "That was part of the [US] Army's Future Combat Systems Programme, which at the time was the Army's largest acquisition effort ever and it was supposed to involve 20-something systems that were supposed to interact and collaborate. The programme was cancelled and only two of those systems where fielded and one was the SUGV." Looking in more detail at the SUGV, Bielat adds that it weighs in at about 30lb and therefore is much lighter than the PackBot, but very similar in the way that it is used and similar in its capabilities: "It can't lift quite as much, its manipulator is shorter, but it is lighter in weight and it has a smaller footprint."

Even smaller than the SUGV is the FirstLook that is a 5lb throwable robot of which 44 were ordered back

in 2017 by the German Government for military and law enforcement. Bielat explains that the FirstLook is even designed to survive a 20-foot drop onto concrete and is primarily for reconnaissance: "We have seen them used heavily in law enforcement in barricaded suspect situations where they throw the robot in and see what is going on inside a building, infantry uses them similarly. It is also capable of supporting a small manipulator and is used to interrogate suspected IEDs."

WEIGHING UP THE SACRIFICES

Bielat agrees that developments have enabled robots to become smaller but as with other commentators feels that there is a need for different-size classes to perform different missions: "The PackBot being larger is more capable and we have a 500lb robot – the Kobra – which is more capable still – but the sacrifice is that you can't transport it as easily. There is a trade-off between size and weight and capability. You can do fewer things with smaller robots, for instance the 5lb robot, but they are more easily deployed and carried and, for example, the FirstLook is throwable."

Staying with smaller-scale solutions, Padraig O'Connor, managing director of Reamda is keen to explain the rationale behind the development of the vendor's low-to-the-ground Remote Disruptor Platform (RDP). O'Connor says that the RDP, which weighs in at just 16kg [about 35 pounds], can be deployed from a larger machine and is helping to address an issue with pipe bombs: "We have a problem in Ireland with criminal gangs who typically use pipe bombs as a method of intimidation and worse. They usually put them up under the passenger footwell and other nooks and crannies in the car." He explains that positioning a device in this way makes it very difficult for larger EOD robots to reach them: "Even if you get the [manipulator] arm in you won't get a position with the weapon."

On the technology front, Colonel Bob Seddon – formerly the British Army's most senior bomb disposal officer – believes that the rollout of modern haptic (force) feedback systems fitted to the claws of manipulator arms are the way forward for EOD operations and build on advances in sensor, transducer and computer technology: "It [haptic feedback] gives the operator the ability to 'feel' what he is picking up."

TO GET 10 PERCENT MORE STRENGTH YOU MAY HAVE MADE YOUR ROBOT ARM 30 PERCENT HEAVIER

In practice, this can stop suspicious items being crushed inadvertently and help to keep the EOD robot itself out of harm's way: "One of the problems that we had with the original manipulators on the Wheelbarrow [originally used in Northern Ireland] was that it was a very strong system and easy to squeeze things to the point where you would damage them. That is the last thing you want to do if you are dealing with explosive items like a detonating cord," he concludes ●

Timothy Compston is a journalist and PR professional who specialises in security and defence issues. He studied International Relations and Strategic Studies at Lancaster University, is PR Director at Compston PR and a previous Chairman of both the National PR Committee and CCTV Section PR Committee of the British Security Industry Association.

The T7's robotic arms are designed with extra joints for added dexterity

Picture credit: Harris Corporation