BREAKING DEFENSE | eBRIEF

Autonomy changes everything about combat engineering

An editorial eBRIEF sponsored by PEARSON ENGINEERING

SITREP

The protracted stalemate in the Ukraine war is in part due to the inability of Ukrainian troops to breach Russian defensive fortifications during their counteroffensive in the second half of 2023. In the months prior to that action, Russia had time to fortify the front lines with obstacles like anti-vehicle ditches, minefields, Dragon's teeth concrete blocks, and Hedgehog barriers.

Such fortifications for defense are built by combat engineers; they're also eliminated by combat engineers to make way for offensive maneuver forces. It's a dangerous job often dependent on massive machines like the U.S. Army's manned 72-ton, 40-foot-long M1150 Assault Breacher Vehicle (ABV) with a dozer blade for mine- and explosives-clearing that is built on an M1 Abrams tank chassis.

The Army recognizes the inherent danger soldiers face operating such machines – not only from mines but from drones and precision fires – and is taking lessons learned from ground robotics programs such as the XM30 Mechanized Infantry Combat Vehicle and applying them to combat engineering missions. The ABV, for example, is now in a prototyping stage to develop the capability for robotic breach with standoff capability.

Combat engineering tasks are sometimes described as dull and dirty, but nonetheless remain a significantly dangerous set of activities. To change that equation, deployment of robotic combat engineering assets will significantly reduce risk to exposed soldiers in the breach, while maintaining or increasing the tempo of movement for maneuver forces.

– Barry Rosenberg
Technology & Special Projects Editor
Breaking Defense

U.S. Army soldiers with the 20th Engineer Brigade begin their convoy to Ashville, NC, at Fort Liberty, NC, Oct. 4, 2024. As part of the homeland defense mission, the Department of Defense, through U.S. Northern Command and in support of FEMA, provides necessary support to civilian authorities in the wake of any natural disasters when directed and approved by the Secretary of Defense. (U.S. Army photo by Cpl. William Hunter)

ON THE COVER: Soldiers with the 130th Engineer Brigade, 8th Theater Sustainment Command, conduct breach training with soldiers assigned to the 25th Infantry Division and Marines with the 3rd Sustainment Group (Experimental) at Schofield Barracks, Hawaii, Aug. 29, 2024. (U.S. Army photo by Sgt. 1st Class Joshua Brandenburg)

Taking the danger out of combat engineering with robotic vehicles

The primary role of combat engineers is two-fold: first, clearing the battlefield ahead using explosives and machines with front-end equipment so maneuver forces can travel forward unhindered, and, second, slowing down opposing land forces with terrain-based effects like Dragon's teeth. These mobility-countermobility roles can be complex and require close integration with maneuver formations to be successful.

Col. Stephen Kolouch is commandant of the U.S. Army Engineer School. (Army photo)

"The combat engineer leads the attack at a place where the enemy is most likely to be best prepared for the attack," said Col. Stephen Kolouch, commandant of the U.S. Army Engineer School at Fort Leonard Wood, which traces its roots to the American Revolution and where combat engineers are trained in the principles of DOTMLPF (doctrine, organization, training, material, leader development, personnel, and facilities).

"Basic principles of land warfare are clear that a defender, especially when given time to prepare, has a very clear advantage over an attacker. This is precisely when the combat engineer is called to the front to perform his/her duties in the breach. It is why breaching is so dangerous and the transparency of the battlefield of today, given the prevalent use of UAS, only makes it more difficult and dangerous."

Such threat scenarios necessitate the need for ground robotics that not only conduct intelligence, surveillance, and reconnaissance, but also combat engineering – and at safer standoff distances for "sappers", a derivative of a French word that identifies combat engineers who support front-line maneuver forces, both mounted and dismounted. The technologies and capabilities enabling robotics are now all in the grasp of possibility because of unprecedented technological advancements in areas like artificial intelligence, autonomy, advanced sensors, and open systems architecture.

"The proliferation of long-range, precision strike capabilities will create a transparent battlefield where soldiers will be under near-constant observation and threat from advancing multi-domain strike capabilities," said Kolouch. "Consequently, we must find ways to reduce the risk to our soldiers and ensure the survivability of engineer forces during large-scale combat operations. The only way to accomplish this is to remove soldiers from the most dangerous parts of the battlefield by using robotic capabilities."

For combat engineers needing to shape the terrain, the most dangerous place they can be during a ground assault is in the breach – an advantageous spot on the battlefield dictated by terrain where attacking forces want to create a lane to maneuver through but are blocked by enemy obstacles. Those barriers were placed at that same point on the map because defending forces also recognize that place as a potential lane for advancing maneuver forces

Also high on the list of high-risk combat engineering tasks is gap crossing to enable mobility and obstacle emplacement for countermobility. Both are time-consuming missions that leave engineers vulnerable to sustained attack.

"Engineers are often leading the ground assault at one of the most dangerous points in any battle," noted Kolouch, who was appointed to the grade of brigadier general in a November announcent. "Robotics, whether autonomous, semi-autonomous, or remotely operated, can be used to replace humans in the breach and save lives. Out of the many uses robotics can and will play in future warfare, the combat engineer task of breaching is very well suited to be replaced by robotics due to the relative simplicity of the task and the high toll on human life that is expected using current breaching methods."

Roles and challenges in robotic combat engineering

As the Army has realized throughout its ground robotic programs and from lessons learned during the Robotic Combat Vehicle (RCV) program, even development of autonomous systems for seemingly less complex tasks like wheeled mules to hump supplies for dismounted forces has not been without fits and starts.

The challenges increase with the complexity of the jobs asked of the machine – made only more so by the continued introduction of artificial intelligence, creation of software and the autonomy stack that controls the vehicles, and especially relevant to combat engineering is the inherent complexity associated with task aggregation and problems caused by the physical environment.

“Robotics can be used to gain a better understanding of the enemy obstacle effort, the terrain, and be used to deliver effects – often explosive effects – into the breach without having humans in that dangerous area,” said Kolouch, who was formerly director of the Office of the Chief of Engineers at Headquarters, Department of the Army. “The challenges are much similar to when humans are performing the breach. How do you ensure it is synchronized, effective against the obstacles, and protected from being immediately destroyed prior to delivering the desired effect?

“Other robotic-specific concerns include ensuring the robotics aren’t able to be used against friendly forces, maintaining situational awareness of where the robotics are on the battlefield, and robotic-specific logistical requirements added to the already difficult logistical picture.”

Enabling technologies for robotic engineering

There are a variety of enabling technologies for these robotic platforms – from the front-end equipment and tools to the autonomy stack that includes everything from LiDAR and cameras to the algorithms and firmware – that are needed for the Army to conduct robotic engineering.

Kolouch laid them out: “The first tech that will help with the problem is a vast array of sensors that can be flown over the obstacle area to gain an understanding of the enemy obstacle effort that was previously unused/unavailable. Next is semi-autonomous robotics that uses waypoint, optical, and/or light detection and ranging [LiDAR]-based navigation that provides previously unavailable standoff for combat engineers in the breach. Lastly, remotely operated via radio link or fiber optics provides a relatively low-tech but still effective means of attaining more standoff than previously available.”

In the area of front-end equipment, the Army is looking for “technology that enables more precision on front-end equipment, aside from just detonating an explosive.”

Applying the Army’s Modular Open Systems Approach (MOSA) that is now being employed in the Future Vertical Lift program, for instance, to robotics and combat engineering vehicles will accelerate both development and acquisition. For example, a standards-based MOSA architecture will allow autonomous behaviors developed for one platform to translate to another.

In addition, ground control units for robotic systems are presently not interchangeable, leading to multiple one-offs that are costly and not scalable. That should change with MOSA, with the ultimate goal being development of one MOSA-compliant ground-control system that can be manufactured by multiple companies and have the ability to control or receive data from multiple diverse platforms.

The Army is working on a tele-operation capability for the M1150 Assault Breacher Vehicle that adds a remote control system. (Army photo)

Legacy systems and autonomy

The Army is currently exploring the possibilities of transforming legacy crewed machines like the Assault Breacher Vehicle into uncrewed systems, and has awarded a contract to develop a teleoperation capability for the ABV called RCV for remote control system.

This will likely be an interim solution for combat engineering as it’s an evolutionary step that does not capitalize on the inherent advantages of attritable robotic systems, according to Kolouch.

“An Assault Breacher Vehicle is a very expensive system that is designed for a specific purpose, to protect combat engineers during explosive and mechanical obstacle breaching. If we are sending unmanned vehicles into an area where we know there is a high likelihood it could get destroyed, we want that vehicle to be as low cost as possible. It is equivalent to shooting down a $100 UAS with a $750,000 missile. It’s not sustainable from an economic standpoint. We want to flip that cost ratio to be in our favor and newly developed manned systems that we make unmanned for high-risk scenarios will never get us to that point.”

What will get the job done, however, are robotic platforms with the ability to employ multiple mission payloads that increase the capability and capacity of engineer forces without the lifecycle costs of a major weapons system.

A prototype version of Pearson Engineering's RCV-Pioneer + Obstacle Clearance Mission Payload was demonstrated on the General Dynamics Land Systems TRX RCV. It included a manipulator arm capable of lifting objects up to 1,100 pounds at max range, a V-shaped dozer blade for moving obstacles, and an area which is designed to carry a variety of different loads. (Pearson Engineering photo)

"As with the software and vehicle subsystems, modularity is the key at the platform level. Taking advantage of a common platform that's already deep into autonomous integration will get us to unmanned capability in engineering faster."

Rather than focusing on purpose-built autonomous platforms, the Army is relying on application of MOSA principles to create modular mission payloads specifically geared toward mobility and countermobility tasks. The key is to complete those tasks in no more time than it would take a crewed system.

"We expect that autonomous capabilities in the engineering community will come on the shoulders of commonality, leveraging platforms that our maneuver colleagues use with engineering-specific payloads," said Kolouch.

Bringing autonomy forward for combat engineering

Under the Replicator program for small unmanned aircraft systems (sUAS), the Pentagon is aiming to accelerate its autonomy efforts to field swarms of affordable, attritable drones. The Army has its own significant autonomy programs as we've discussed, though nothing on the order of anything specifically for combat engineering.

That doesn't mean, however, that the use of autonomy in combat engineering can't be accelerated – even after acknowledging that developing a robot to autonomously maneuver across terrain is significantly more complicated than asking a drone to conduct ISR.

"We must change the way we procure and incorporate technology," said Kolouch. "In many instances, we must move away from exquisite, expensive, and highly specific platforms toward common, scalable, and modular platforms that are capable of applying mission-specific payloads.

"As technology improves and matures, we can develop, test and field new payloads from across the industry much faster than conventional acquisition processes allow because they will fall within the parameters of existing programs. This could also mean that we re-look at how we account for these payloads, especially for technology that matures quickly and quickly becomes obsolete or is consumable/attritable."

"The Army's Modular Open Systems Approach, from software to hardware, including energy and power systems, provides strong and lasting benefits to the force such as the ability to develop behaviors that enable us to increase capabilities of RAS systems over time."

The Army's recently established initiative called human-machine integrated formations, for example, was created to bring robotics into maneuver formations through experiments and demonstration, and see how autonomous systems can take over the especially dangerous battlefield missions related to first contact with the enemy in the breach.

Kolouch pointed to the Sandhills Breaching Project out of XVIII Airborne Corps in late 2023 that was executed by the 20th Engineer Brigade as an experiment designed to begin moving toward that goal.

Autonomy for combat engineering can also be brought forward through a capability/task focused modernization model, which differs from how the Replicator program for UAS is structured.

"Programs such as the Replicator are great, but they are platform-centric, meaning we are going to build a bunch of these platforms and give them to the DoD to figure out how to use them to accomplish their tasks," said Kolouch. "A capability or task-centric approach looks at specific tasks we use robotics/autonomous systems to accomplish, and we drive the industry to help us accomplish those tasks.

"This is a bit nuanced, but it makes a difference. This approach can help the industry better understand the problems we need solved as opposed to working from an ever-changing and evolving list of requirements. This is being done in some cases, of course, but we would like to see it done more."

An unmanned aerial system produced by Lawrence Livermore National Laboratory lifts off during the Sandhills Project 3.0 at Fort Liberty, NC, July 10, 2024. The Sandhills Project is an experiment to deliver robotic, autonomized breaching solutions to large-scale combat operations. (U.S. Army photo by Spc. P S Bailey Whilden)

Developing CONOPS for autonomous engineering vehicles

Demonstrations and projects like Sandhills that get autonomous systems into the mud with engineer soldiers and the operational force will also lead to the creation and honing of new concepts of operation for robotic combat engineering. Parallel efforts in human-machine integration across the Army for how maneuver and other formations will employ robots simultaneously with humans will inform and drive how engineers nest and support these efforts, said Kolouch.

"Unmanned robotic systems will be part of our formations in the near future, and quite frankly they need to be sooner rather than later. We must gain an understanding of how we will integrate these robotics into our formations, and we must prioritize using robotic systems in places where our soldiers are most likely to make contact with the enemy.

"CONOPS and table-top exercises are a good start, but only talking about it will not provide the understanding we need. We must create 'communities of action' that are actively doing things that provide a level of understanding that cannot be achieved through talk alone. The Army's Transforming in Contact initiative is helping get after this concept and it is important that the engineer community continues to embrace the initiative and provide the solutions that will enable us to win now and in the future."

Lastly, programs such as the XM30 are likely to include lethal or kinetic effects. That means weaponry could find its way onto autonomous engineer robots, too. CONOPS should also be informed by risk considerations such as this.

Said Kolouch: "For engineers, this is important for the explosive and kinetic aspects of breaching and especially important for countermobility where lethal effects are employed. CONOPS are fundamental to developing the algorithms that will enable autonomous operation. Robots will operate with soldiers, they need to know not to run over the personnel operating around them but simultaneously need to know to not veer off course on a lane in a minefield."

VIEWPOINT FROM PEARSON ENGINEERING

COMBAT ENGINEERING CAPABILITY EVOLVES WITH AUTONOMY

Pearson Engineering's latest developments include solutions that incorporate tele-operation, automation, and autonomy for front-end equipment and engineering mission packs designed specifically for robotic platforms. We discuss autonomous combat engineering with Amish Patel, senior engineer for robotics solutions at Pearson Engineering.

Amish Patel is senior engineer, Robotic Solutions, Pearson Engineering

Pearson Engineering focuses on the medium tier of RCVs that are in a weight class suitable for combat engineering roles. Which RCVs are we talking about, to execute what combat engineering tasks? What are the combat engineering challenges for this tier of robot?

The medium tier of RCVs, or the RCV-M variant tier, per the U.S. DoD's classification, encompasses robotic vehicles that fall within the 10-20 ton weight category. Having a greater vehicle mass is favoured for combat engineering tasks requiring ground engaging front-end equipment.

The medium tier of RCV's is lighter than traditional armoured engineering vehicles. Ground engaging combat engineering equipment for use with these RCV's will need to be designed to fully utilise the available tractive effort from the host RCV.

Example combat engineering tasks could include route proving and clearance, gap crossing, minefield breaching and urban obstacle creation and reduction.

Tell us about your enabling technologies and solutions for these robotic platforms – the front-end equipment and tools that help the Army complete a task.

Our latest developments include solutions that incorporate tele-operation, automation and autonomous capabilities to front-end equipment and engineering tools designed specifically for robotic platforms. Such developments have been designed to be modular and scalable, allowing them to be mounted onto RCV-Ms from multiple OEMs.

Through the use of integrated sensor technologies and digital tools, augmented operator aids can be implemented to simplify tele-operation of front-end equipment and engineering tools. For example, graphical overlays can be used to aid depth perception when teleoperating manipulator arms, increasing operational tempo and reducing mission completion times.

Integration with battlefield management systems

BMS systems could provide the networking backbone to enable autonomous control of multiple RCV platforms to simultaneously complete combat engineering tasks and missions at pace. Other sensor payloads integrated in the same BMS could also provide RCVs with increased situational awareness to execute tasks with greater precision and momentum.

Describe your RCV-Pioneer concept, which involves developing modular, swappable payloads for RCV platforms rather than building the vehicles themselves. How does this capability reduce the time it takes to reduce an obstacle or breach a minefield?

RCV-Pioneer provides uncrewed ground vehicles with robotic engineering capability, paving the way for modern combat engineering CONOPS. Leveraging the power of mature artificial intelligence and autonomy will allow for robotic engineering assets to work together as a force multiplier, increasing survivability and freedom of movement.

Such technologies will enable UGVs to rapidly interchange modular mission payloads in a matter of minutes, providing vast flexibility for dynamic mission profiles. This increase in the quantity and diversity of robotic combat engineering units in warfare will enable simultaneous execution of engineering operations across the battlefield, creating an unprecedented pace of advancement for friendly forces to counter the adversary with minimal risk to personnel.

The use of autonomous systems will allow for advanced analysis of the mission profile, including the ability to rapidly simulate outcomes with a given RCV and MMP combination when applied in different ways. The optimal set of steps to reduce the obstacle or breach a minefield can then be identified and the RCV and MMP subsequently deployed to execute at pace.

Describe your views on the need for CONOPS around the employment of autonomous engineering vehicles for combat engineering.

Employing robotic engineering vehicles will require a new set of CONOPS to be developed to fully utilise the benefits that robotic platforms can provide. For example, robotic assets could be deployed in an autonomous manner to jointly undertake combat engineering tasks, however a human-in-the-loop may still be required to tele-operate platforms when faced with a scenario that the autonomous system cannot overcome.

The C2 networking backbone would also need to be optimised to account for the bandwidth of all robotic assets that are deployed; integrated autonomy would inherently reduce this burden. CONOPS will need to factor in a means by which the humans operating in partnership with the autonomous engineering vehicles are able to understand how the vehicles are executing the mission. This will be important to build operator trust in autonomous systems and limit unnecessary intervention that may hinder progress. CONOPS will need to take account of how the autonomous engineering vehicle behaves if comms to the command centre are lost or the platform is immobilised, temporarily or permanently.

What is your perspective on the potential for upgrading existing crewed engineering vehicles to provide autonomous capabilities, such as the M1150 Assault Breacher Vehicle?

Pearson Engineering has successfully developed and tested tele-operation kits which can be retrofitted onto existing engineering vehicles, such as the M1150 ABV. One of the main capabilities of the system is that the vehicle can be switched between remote and manual control at the flick of a switch, allowing for fast changeover when used for dynamic mission profiles.

Our retrofittable tele-operation kits reduce the burden of operator training through familiarity of existing platforms and provide a safe path to deploy tele-operated assets and remove soldiers from harm's way sooner. Retrofitting existing crewed engineering vehicles to provide teleoperated or autonomous combat engineering capabilities could be a cost-effective alternative to developing robotic platforms from the ground up. It is an approach that enables combat engineering tasks to be automated and soldiers removed from harm's way in the nearer term, ahead of advanced RCV's coming into service.

Final thoughts?

As technology advances and ground vehicles evolve, we are keeping pace by offering a modern approach to engineering capability in what is quickly becoming a remote and autonomous world.

The development of RCV-Pioneer follows the core principles of Pearson Engineering's approach, providing high levels of equipment flexibility to support mission adaptability.

Whilst best known for providing a suite of tools for vehicles such as the Assault Breacher Vehicle, Pearson Engineering's investment in research and development is seeing us deliver a new generation of capability that will ultimately take soldiers away from the most hazardous tasks.

PEARSON ENGINEERING

Breaking Defense thanks Pearson Engineering for supporting this editorial eBRIEF. Sponsorship does not influence the editorial content of the eBRIEF.