Naval R&D and Marine Corps Innovation

Advancing assault breaching

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For years during the war in Afghanistan, coalition forces rarely entered the city of Now Zad because it had become so infested with improvised explosive devices.[1] In December 2009, however, Marine Assault Breacher Vehicles (ABVs) launched 24 mine-clearing line charges, breaching 6 lanes and allowing Marines to attack the Taliban stronghold, which deteriorated quickly.[2] One Taliban radio transmission directed, "Get out. The big boom is coming."[3]

In recent years, assault breaching capabilities against mines and improvised explosive devices (IEDs) have improved to such a degree that they provide coalition forces with a warfighting advantage in Afghanistan. These improvements resulted primarily from Marines working with naval research and development (R&D) personnel, particularly those in a field called "energetics," the study and application of chemical energy–releasing materials including explosives, propellants, and pyrotechnics. In the future, assault breaching will get even harder, requiring an ever more close relationship.

Marines setting up an antipersonnel obstacle breaching system. *(Photo by LCpl Jeff Drew.)*

Speed Counts

Marines have long sought to detect and avoid mines but recognized that doing so is not always possible. Developed in the 1950s, the line charge was fielded for rapid breaching by assault amphibious vehicles. It has since evolved into the present mine-clearing line charge (MICLIC). When fired, a rocket tows a 1,750 pound, 350-foot line of explosives that detonate, setting off threat explosives vulnerable to blast overpressure. It clears 92 to 95 percent of such mines in a 50-foot-wide and 300-foot-long area.[4] A plow-equipped vehicle would then "proof," or clear, any remaining mines for the attack.[5]

But the need for improved assault breaching became apparent as mines proliferated. In the battle of Kursk, the Russian Army employed tens of thousands of mines against Germany's Army.[6] In Operation Desert Shield/Desert Storm, Iraqis laid 7 million mines in Kuwait.[7] Coalition units entering Kuwait on 14 February 1991 had to breach 2 major minefields containing an estimated 3.5 million mines.[8]

GEN Norman Schwarzkopf called Marine breaching a "textbook operation," but a Marine battalion commander later said, "Mine technology is way ahead of countermine technology."[9] Breaching was slow and risky. A tank towed and launched a trailer-mounted line charge. The tank then covered a second tank that plowed or proofed a lane.[10] The process repeated itself, but not easily. Just over half of the line charges worked properly. Some arresting cables snapped, preventing command detonation. Fuzes failed, causing Marines to exit vehicles and detonate charges.[11] Tank plows did not work well.[12] It took the 2d MarDiv almost 8 hours to breach a dense and sophisticated minefield, with tanks running low on gas and refueling tankers replenishing them—in between minefields.[13 14]

In the 2003 advance on Baghdad, the Marine Corps again experienced what it called "major deficiencies" in assault breaching and mine countermeasures.[15] Because of command and control problems and the speed of coalition forces, Iraq was unable to lay huge minefields like those in DESERT STORM. Still, units across I MEF encountered landmines and suffered casualties, yet much of the countermine capabilities resided in combat engineer battalions.[16] Use of tanks for proofing was seen as degrading their tactical performance.

At the same time, there was another growing threat. Prior to the 2010 attack on Marjah, Afghanistan, then-BGen Larry Nicholson stated, "This may be the largest IED threat and largest minefield that NATO has ever faced."[17]

Countering Mines/IEDs and the Role of Energetics R&D

To address these threats, the Marine Corps initiated the MAGTF Mine Countermeasures Master Plan. This plan encompasses many measures involving multidisciplinary R&D initiatives and is integrated into needed systems. Central to such integrated system developments is energetics R&D (the study and application of chemical energy–releasing materials explosives, propellants, and pyrotechnics), which is done at the Naval Surface Warfare Center, Indian Head Explosive Ordnance Disposal Technology Division (NSWC IHEODTD), in Indian Head, MD. This understanding of energetics is needed to counter explosive threats. Specifically, the division's energetics experts aid mine countermeasures development through the following:

- *Informing intelligence and characterizing explosive threats.* This informs development of detection, neutralization, and mitigation measures.
- *Developing detection measures.* Knowing Afghan IEDs use homemade explosives, NSWC IHEODTD's energetics experts developed detection kits that are now carried by Marines.
- *Developing neutralization means.* These may be explosive, mechanical, or chemical. For example, NSWC IHEODTD developed a dart-like projectile with diethylenetriamine that penetrates mines, burning the TNT fill.
- *Developing mitigation.* Warfighters' helmets now have sensors that measure blast pressures. These sensors then can be screened, helping medical personnel identify and treat brain injuries and better prevent permanent ones. NSWC IHEODTD energetics experts also aided in developing this sensor.

Mine countermeasures also include assault breaching. It was Marines partnering with an interdisciplinary R&D effort, and the energetics experts central to that research, that resulted in assault breaching capabilities, thus a warfighting advantage in Afghanistan.

Assault Breacher Vehicle launching a mine-clearing line charge. *(Photo by Cpl Jeff Drew.)*

Improved Assault Breaching: The Difference in Afghanistan

In his book, *First to Fight*, retired Marine Corps LtGen Victor H. Krulak wrote of Marines' "innovative brilliance."[18] Such is the case with Marines' Anniston Army Depot–produced ABV, which went from PowerPoint slides in 2002 to fully mission-ready in 2007. To some, this would have been impossible. "Industry could not accomplish what you did," stated program manager William Macecevic, Marine Corps Systems Command, while addressing depot personnel in 2012.[19]

The vehicle does what two vehicles once did, thus speeding assault breaching. Built on an M1A1 tank chassis, the ABV's turret was designed to launch 2 line charges for explosive breaching. The vehicle also has a 15-foot plow, digging 14-inches deep for proofing/mechanical breaching. It moves up to 50 miles per hour, and 5 to 8 miles per hour when plowing.[20] The ABV can take multiple IED hits and keep going.[21] Referring to the vehicle's faster breaching, one Marine combat engineer stated, "It speeds up the process almost ten-fold."[22]

The vehicle was rapidly fielded to meet an urgent need, but its development and testing continues, with energetics R&D being integral. This

R&D addresses the explosive breaching—the MICLIC—helping it operate reliably, quickly, and safely. Working with Marines and other R&D areas, the division's energetics experts enable the following:

- *Interoperability.* The vehicle and line charge are two separate systems that must work together. Energetics experts initially found potential interoperability issues between the vehicle's fire control and line charge rocket motor, the MK 22. NSWC IHEODTD produced MK 22s specifically tailored for use with the ABV and shipped these assets to Marines in Afghanistan. This experience is also informing interoperability efforts for the amphibious assault vehicle and its upgraded line charge fire control.
- *Reliability.* Despite improvements, MICLICs, which are designed for on-command detonation, have sometimes needed to be manually detonated.[23] MICLICs consist of three 100-foot sections and one 50-foot section, each with sensitive primers that transfer the detonation. To enable more reliable detonation transfer, NSWC IHEODTD developed an overbraid technology that will make line charges continuous.
- *Faster and safer operation.* Currently Marines have to pop vehicle hatches and cut line charge cables so they do not tangle tracks. To prevent Marines from being unnecessarily exposed to enemy fire, energetics experts initially provided a cartridge-activated mechanism that fires a knife through the cable when the line fully deploys. In development is a mechanism possibly using explosive bolts to release the cable. Marines in Afghanistan have helped by sending pictures of the mechanisms, both prefiring and postfiring, back to the engineering community, providing a unique insight.
- *Safer line charges.* Two line charges—nearly 2 tons of explosive—sit atop the vehicle's turret. While laser-cut metals and fabric panels protect the charges, energetics experts have reduced risks of unintended detonation, by:
  - Incorporating explosives, including detonation cord, less sensitive to friction and other influences.
  - Incorporating explosives that are less sensitive to bullet and fragmentation impacts, and are designed to burn in a fuel fire–cook-off scenario.[24]
  - Preventing electromagnetic radiation from initiating rockets and energetic devices.

ABVs have made a difference. Marines call them the "answer" to IED-intensive areas, which they rapidly punched through, enabling Marine attacks in Now Zad and Marjah.[25] [26] ABVs also cleared urban areas. With inhabitants' permission, Marines fired 35 line charges, clearing multitudes of IEDs in the bazaar of one Afghan town.[27] ABVs have also enabled lifelines. Due to constant IED employment around its operating base, convoys could not resupply a Marine platoon, but ABVs breached the way for resupply.[28]

Assault Breacher Vehicles prior to Operation BLACK SAND, 2011. *(Photo by Cpl Jeff Drew.)*

"I consider it to be a truly lifesaving weapon," said Marine combat engineer GySgt Steven Sanchez.[29] (Search for "Assault Breacher Vehicle" at YouTube.com for more information.) The proof is also in the numbers. By 2012, the Marine Corps had procured 52 ABVs, with the Army planning to procure 187.[30] [31]

Another Marine innovation changing assault breaching and warfighting in Afghanistan is the two-man version of the line charge called the Anti-Personnel Obstacle Breaching System (APOBS). The APOBS comes in 2 backpacks weighing nearly 60 pounds each and doing what was done by three 450-pound Bangalore torpedo kits. Deployable in 30 to 120 seconds, the APOBS launches a rocket, towing a line charge that is comprised of grenades. Upon detonation, it breaches a path 2 feet wide and 150 feet long.

NSWC IHEODTD invented much of the technology for APOBS and subsequently has continued to aid in production. The division's energetics experts helped develop the previously mentioned over-braiding technology, making the line charge less manufacturing-intensive. They also helped the manufacturer form the bulk explosive, improving production quality and rate. NSWC IHEODTD presently produces rocket propellant grains, as industry lacks the capability.

This two-man line charge was fielded prior to Operation IRAQI FREEDOM in 2003, but was not initially appreciated. One Marine questioned, "Why should I lug a 50-pound piece of gear around that only clears 25 meters when I can just mark it for [explosive ordnance disposal] and walk around the obstacle?"[32] The answer to this question came later, as it gave foot-mobile ground units an assault breaching capability that had mostly resided with combat engineer units, allowing them to go where ABVs could not.[33] Using the system, Army and Marine patrols breached IED-infested trails in Afghanistan.[34] (Search for "Marines clear Taliban IED with APOBS in Kajaki" at YouTube.com for more information.)

Collectively these assault breaching capabilities helped take the fight to the

Taliban. A 2012 U.S. Army study stated the following:

> Advanced weapons systems, such as MICLIC-firing ABV and APOBS, also gave the Americans a distinct advantage over the enemy embedded in a safe haven that dated back to the Soviet-Afghan War.[35]

Solving Tomorrow's Assault Breaching Problems

This past is prologue for the future. Marines and R&D personnel (particularly in energetics) have worked closely to develop assault breaching capabilities, which epitomized the warfighter-R&D relationship addressed in Paul Kennedy's *Engineers of Victory: The Problem Solvers Who Turned the Tide in the Second World War*. As Kennedy wrote, leaders "encouraged problem solvers to tackle large, apparently intractable problems."[36] The Marine-R&D relationship is needed to solve future problems.

The mine/IED threat is increasing, and their breaching is the seemingly intractable problem. Regarding landmines alone, the International Campaign to Ban Landmines reported in 2013 that 32 states stockpile 160 million antipersonnel landmines, 12 produce landmines, and 59 are affected by mines in some way.[37] Some cost as little as $3 to produce.[38] Some are advancing in lethality and fuzing. Additionally, "the global proliferation of IEDs and associated technology is pervasive," as stated by the Director, Joint Improvised Explosive Device Defeat Organization, before congress in July 2012.[39] As seen in Iraq and Afghanistan, maneuver cannot always avoid these threats.

Marines are defining future breaching problems, the solutions for which may be feasible. "Maneuvering forces will have the ability to detect and neutralize mines and IEDs from sufficient stand-off distance," states *2012 Marine Corps Science & Technology Strategic Plan*.[40] Unmanned systems may provide neutralization, which has been demonstrated with an unmanned ground iRobot launching an APOBS.[41] Energetics R&D can develop smaller and more lethal assault breaching systems for faster unmanned systems.

Rapid neutralization is also needed for deeper buried mines/IEDs. Based on research, shaped charges may provide this neutralization. Working closely with intelligence, energetics experts can characterize threat explosives and then determine how deep shaped charges will penetrate to knockout buried mines/IEDs. Such shaped charges may be integrated into mortar rounds and other munitions, providing standoff neutralization. Also, much of the blast from a line charge goes into the air. Technologies can orient line charges, thus focusing blasts downward, enabling deeper ground penetration.

The assault breaching mission presents a significant challenge right from the starting line. The large area of mines and obstacles to be cleared in the surf zone and on the beach warrant a system-of-systems approach.

The assault breaching mission presents a significant challenge. . . .

The Joint Direct Attack Munition Assault Breaching System is an air-delivered weapon available to support the mission now. The Countermine System will complement the Joint Direct Attack Munition Assault Breaching System, and its technology could be adapted for other missions. The air-launched munition delivers 6,000 explosive darts that were developed at NSWC IHEODTD. These darts explode upon penetrating, neutralizing surface-laid and buried mines, and mines in the surf zone, to include blast-resistant mines. After delivery, these darts also could be disarmed by tiny, NSWC IHEODTD–developed, energetic "microelectromechanical systems." Additionally, payloads with fewer darts might be developed for direct and indirect fire weapons systems.

Scalable breaching is also needed. Firing line charges for one or two mines/IEDs expends a lot of breaching capability that may be needed later. Scalable breaching may be possible with existing munitions delivering either the previously mentioned shaped charges or darts.

A Partnership That Succeeds

Assault breaching improved because Marines and naval R&D worked together. Some may see this partnership as unlikely, but the similarities between Marines and naval R&D enable the impossible, even when many think otherwise. As they confront problems critical to the Nation, Marines in the battlspace and R&D personnel on the frontiers of science *both* persevere in the face of uncertainty, and are unified because of it. The greatest similarity between Marines and naval R&D, though, is that they realize solutions, a dynamic best described by philosopher Eric Hoffer: Marines and naval R&D "think beyond the moment; [and] live beyond the day." Such a partnership succeeds.

Notes

1. Nola, Cpl Zachary, "Marines clear Taliban stronghold during Operation Cobra's Anger," article available at www.dvidshub.net.

2. McLeary, Paul, "Long Legs, Fast Blades," *Aviation Week & Space Technology*, Washington, DC, 8 February 2010.

3. Pappalardo, Joe, "Big Booms for Safer Roads: Marine Corps engineers in Afghanistan have a new beast of a vehicle to defeat explosive booby traps," *Popular Mechanics*, New York, 1 April 2010, available at www.popularmechanics.co.za.

4. "A Brief Survey of Mine Breaching Capabilities," The Dupuy Institute, McLean, VA, 23 August 2000, available at www.dupuyinstitute.org.

5. Ibid.

6. Kennedy, Paul, *Engineers of Victory: The Problem Solvers Who Turned the Tide in the Second World War*, Random House, New York, 2013, p. 193.

7. Houlahan, Thomas, "Mine Field Breaching in Desert Storm," Harrisonburg, VA, December 2001, available at maic.jmu.edu.

8. Ibid.

9. Gordon, Michael R., and LtGen Bernard E. Trainor, *The Generals' War*, Back Bay Books, New York, 1995, p. 360.

10. Houlahan.

11. Ibid.

12. Ibid.

13. The Dupuy Institute.

14. Gordon and Trainor, pp. 359–60.

15. "Marines address deficiencies in defeating mines," *Jane's Defence Weekly*, London, 19 November 2004.

16. Ibid.

17. Lister, Tim, "Bulldozer-tank hybrid takes out minefields," CNN, Atlanta, 12 February 2010, available at afghanistan.blogs.cnn.com.

18. Krulak, LtGen Victor H., *First to Fight: An Inside View of the U.S. Marine Corps*, U.S. Naval Institute Press, Annapolis, MD, 1984, p. 88.

19. Bacchus, Jennifer, "Anniston completes first ABV production run for Marines," Anniston Army Depot, AL, 1 March 2012, available at www.army.mil.

20. De Montesquiou, Alfred, "Marines push 'The Breacher' against Taliban lines," *Marine Corps Times*, Springfield, VA, 11 February 2010, available at www.marinecorpstimes.com.

21. Bacchus.

22. Murray, LCpl Jonathan, as quoted in "The Assault Breacher Vehicle," posted on Combat Tech, accessed at military.discovery.com.

23. Wright, Donald P., editor, *Vanguard of Valor, Volume 2: Small Unit Actions in Afghanistan*, Combat Studies Institute, Department of the Army, Washington, DC, p. 5, available at usacac.army.mil.

24. Bacchus.

25. Staff, "This Assault Breacher Might Be The Most Bizarre Thing You'll See All Weekend," *The Business Insider*, New York, 22 February 2013, available at www.businessinsider.com.

26. CNN.

27. VonDerAhe, Cpl Clayton, "Mine-Clearing Line Charges pave way for ground troops," posted on 2dMarDiv.marines.mil, Camp Lejeune, 4 April 2012, available at www.2ndmardiv.marines.mil.

28. McCall, Cpl John, "High Maintenance Vehicles Run by High Performance Marines," *The Globe*, Camp Lejeune, reporting from Bahram Chah, Afghanistan, 20 March 2011, available at www.dvidshub.net.

29. De Montesquiou.

30. Bacchus.

31. Staff, "New USMC Technology Blasts Into Afghan Town," *Aerospace Daily & Defense Report*, Washington, DC, 6 January 2010, available at www.teoti.com. The news item states, "The U.S. Army also has plans to buy 187 ABVs in the coming years, a handful of which have already been produced."

32. Marine Corps Systems Command Liaison Team, "Field Report: Central Iraq," 20 April to 25 April 2003, p. 10.

33. Denham, PFC Shawn, "Engineers teach Infantrymen demolitions, route clearance," *Fort Campbell Courier*, Fort Campbell, KY, 7 October 2010, available at www.fortcampbellcourier.com.

34. Wright, p. 9.

35. Ibid., p. 21.

36. Kennedy, p. 367.

37. International Campaign to Ban Landmines, Landmine Monetar 2013, Geneva, Switzerland, March 2013, accessed at reliefweb.int.

38. Hanlon, Mike, "The land mine—one of history's cruelest inventions," *Gizmag*, 14 September 2006, available at www.gizmag.com.

39. Gaskill, Stephanie, "IEDs increasingly a U.S. threat," *Politico*, 12 July 2012, available at www.politico.com.

40. Headquarters Marine Corps, *2012 Marine Corps Science & Technology Strategic Plan*, Washington, DC, 17 January 2012, p. 14, available at www.onr.navy.mil.

41. "iRobot 710 Warrior with APOBS," video available at www.youtube.com.