Enhancing Mortar Capabilities

A premium indirect fire support system

by Christine Michienzi

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"I would say probably half the guys we killed, we killed with mortars,' stated one Marine infantry battalion commander. Afghanistan has placed a premium on indirect fire systems, notably mortars.[1]

Marines on the cutting edge may not give a lot of thought to naval labs, but we in naval labs think about Marines almost daily. We follow warfighting problems and provide technical improvements when needed. Such is the case with mortars. Their range, precision, and lethality can be improved using technologies developed at the Naval Surface Warfare Center, Indian Head Division (NSWC IHD) and other naval labs.

Reach Out and Touch

Compared to Iraq, indirect fire systems have played greater roles in Afghanistan. In Iraq, firefights often occurred in urban areas, with extensive use of direct fire systems—rifles, machineguns, rocket launchers, etc. In Afghanistan, reports indicate that over 50 percent of the engagements occur beyond 300 meters[2] and sometimes out to 1,000 meters.[3] Additionally, knowing that it faces a heavier opponent, the Taliban has sought higher mountainous terrain, engaging with medium and heavy weapons to include mortars.[4]

In Afghanistan's complex terrain, mortars have received increased emphasis. First and foremost, they significantly outrange direct weapons. "If you want it killed, use your mortars," stated one SNCO in Afghanistan.[5] Their high-angle fire enables engagement on backsides of mountains[6] better than artillery howitzers, which have flatter trajectories. And they have other uses besides attacking distant targets. Their nighttime illumination has helped detect enemy movements and emplacements of improvised explosive devices.[7] Mortars have also laid smoke for screening friendly units' movements.[8]

Additionally, mortars are more responsive than other supporting arms, largely because they belong to infantry units. Mortars can get on target faster than artillery, the latter taking several minutes. The delay with artillery has been recognized by the Taliban who, after engaging, often disperse before rounds fall. They have done the same upon hearing aircraft inbound for close air support. And mortars are more likely to be on target than air support in Afghanistan's notoriously bad weather.[9]

Yet warfighters want and need more from these weapons. "While mortars may provide a quick response, they still lack the punch, mass, and range to support the fight in Afghanistan for the long-term," writes an Army officer.[10]

Mortar systems play an important role in Afghanistan. *(Photo by LCpl James W. Clark.)*

There has also been a huge demand for precision. While an urgent operational need called for precision 120mm mortars,[11] some advocate precision 60 and 81mm mortars.[12] And the Navy's research and development budget for 2012 plans to "[i]nitiate development of [a] precision 60mm mortar system, to demonstrate increased precision, range, and lethality in a light mortar . . . ."[13]

Within the U.S. mortar family, the 81mm mortar is seen as the most deficient. Weighing 89 pounds, it is too heavy for foot-mobile patrols, and its range is 5,700 meters, less than the 120mm mortar. "Because of their inability to range the adjacent terrain around FOBs [forward operating bases], 81mm mortars are frequently of marginal value on anything other than mounted patrols," wrote four former Marine battalion commanders, with a total of 27 months of command in Afghanistan.[14] The 81mm mortar needs greater range, at the very least.

Longer, More Accurate, and Lethal Delivery

Much of the scientific effort undergirding warfare has been dedicated to making weapons shoot farther, faster, and against tougher targets. That has been a role of the NSWC IHD for over a century. From naval gunfire's expanded ranges enabling amphibious assaults in World War II to more compact thermobaric weapons used at Fallujah, Indian Head has provided technical solutions for warfighting problems. Today technical improvements exist for mortars, particularly the 81mm mortar. Conceivably these improvements could make it more like the present 120mm mortar.

Increased range has been achieved under the Extended Range Mortar Ammunition Program, sponsored by the Office of Naval Research. It has expanded the 81mm mortar round's range by 20 percent—out to 6,700 meters—and it could provide a similar increase in range for other systems, to include the 60 and 120mm mortars. Extending this range led to the development of a new propellant, because using more of the old propellant simply wouldn't work. It would increase pressure and erosion in the mortar tube, reducing service life. It also would increase temperatures in the tube, raising the likelihood of the next round's cookoff. And, more of the old propellant had human consequences. In addition to added logistics, its ignition would increase blast overpressure and noise levels, possibly injuring crews.

Increased range has been achieved under the Extended Range Mortar Ammunition Program. ***(Photo by LCpl Garry J. Welch.)***

Thus IHD scientists developed a nitramine propellant, providing significant advantages for the 81mm mortar, beyond just extending range. This propellant was formulated to burn at a more controlled and tailored rate compared to the old propellant. In other words, the new propellant's combustion pushes the round longer in flight relative to the old propellant. This new propellant's more controlled burning rate was enabled by using high-nitrogen compounds, as well as adjusting the granulation or shape of the propellant grains.

This new propellant extends the 81mm mortar round's range, which was demonstrated during numerous tests at the Yuma Proving Grounds in August 2008, August 2009, and December 2010. But it has other advantages for the 81mm mortar. Relative to the old propellant, it reduces wear and erosion on the tube, increasing service life and

The propellant's chemistry is more reliable and safer. *(Photo by LCpl Garry J. Welch.)*

reducing life cycle costs. Additionally, it reduces flames and temperatures in the tube, decreasing cookoff potential and possibly increasing rate of fire.

This propellant's chemistry is also safer and more reliable than old propellants. It eliminated nitrate esters, which made propellants more sensitive to unplanned initiation. This makes it a "low-vulnerability ammunition" and likely more compliant with the Defense Department's insensitive munitions requirements. Elimination of nitrate esters also prevents performance changes in the propellant over time and enables the propellant to have a longer and more stable shelf life.

Enabling precision is being developed. In March 2011 Army units in Afghanistan received precision guided 120mm mortar cartridges. The previous and less accurate cartridges had a "136-meter circular error probable," meaning rounds fell inside a circle with a 136-meter radius 50 percent of the time. The new precision cartridges have a "76-meter circular error probable," making them seven times more accurate than any fielded mortar.[15] However, the operational urgent need calls for a "10-meter circular error probable."[16]

An Office of Naval Research initiative is developing a capability that could improve precision for all mortar systems. For example, it could provide an 81mm mortar round that will hit in a 5-meter radius around a target 90 percent of the time. Such precision would allow 81mm mortars to engage targets between buildings and in terrain that traditional ballistic munitions cannot. Doing so will minimize collateral damage. Also, enhanced precision means fewer rounds on targets, which could reduce logistics.

This precision requires a "flight controlled mortar round," using a global positioning system or semiactive laser designator to guide it to a target. Integrating these components into an 81mm mortar round (or a 60mm round for that matter) is a lot harder than doing that with the 120mm mortar. There is less space in the smaller 81mm mortar round, and adding electronics means increasing weight, which means decreasing range. The solution lies in freeing up space and weight in the existing 81mm mortar round. This can be done by replacing the present fuze, weighing about a half-pound, with a miniature fuze—a microelectromechanical system (MEMS). It is smaller than a dime in size and weight. This technology has been used in communications, automotive, and biomedical fields. In 1995 NSWC IHD scientists and engineers began developing MEMS technology for weapons fuzing, and this technology is now used in naval weapons systems. Additionally, MEMS fuzes provide more capability with enhanced reli-

ability while reducing life cycle costs. They offer the same for other weapons too. A precision 81mm mortar round with a MEMS fuze is expected to be demonstrated in 2014. Plans also call for it to use the new nitramine propellant.

Increased lethality can be achieved for all mortars. As an example, the M889 high-explosive 81mm mortar round weighs about 10 pounds, carrying about 1 pound of explosive. Upon detonating, it fragments the round's casing, creating shrapnel that impacts a target with kinetic energy. This shrapnel is just inert steel. Imagine, however, shrapnel that impacts a vehicle or weapons system with kinetic energy, as well as a highly destructive chemical energy producing immense heat and causing intense sustained pressure. This casing material would give the mortar round greater destructiveness per pound.

Such a mortar casing could be formed with "reactive materials." Such material is chemically formulated to be strong and completely insensitive for handling, but upon detonation of the mortar, the shrapnel impacts the targets and releases tremendous energy. This can occur because either the case material components react with each other on impact or combust violently in air. Such reactive material projectiles can penetrate a system's outer skin and then ignite upon impact with internal components, producing heat and pressure that rupture the system from the inside out. The result is catastrophic damage, far more significant than previous munitions.

The IHD has developed the highest performing structural reactive material with the density of steel. Dubbed HDRM for high-density reactive material, the material can be formed or machined into varying structures and used to replace the inert steel components of weapons systems with little or no design impact. The result is a dramatic increase in the ordnance energy density and consequently its lethality.

Since the mid-1990s, reactive materials have been developed and evaluated for weapons uses.[17] Recently the Navy successfully completed a demonstration of a reactive material-enhanced warhead for antiair applications. Even more relevant, Germany has demonstrated an 81mm mortar round using a reactive material.

It's What We Do

Every day Marines put it on the line for us, and we never forget it in the labs. Our thoughts as well as our hearts are with them out of gratitude and out of desire to help. As scientists and engineers we can do that with mortars, making them better than they are today and in ways needed for the future. And we can do that with other systems as well, because that's what we do. Maintaining the Marines' technology edge is how we serve.

A precision 81mm mortar round with a MEMS fuze is expected to be demonstrated in 2014.

Notes

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11. Exhibit R–2, Research, Development, Testing and Evaluation (RDT&E) Budget Item Justification: PB 2012 Army, PE 0604802A: *Weapons and Munitions - Engineer Development,* February 2011, p. 1.

12. Grant.

13. Exhibit R–2A, RDT&E Project Justification: PB 2012 Navy, PE 0603640M: *MC Advanced Technology Demo* (firepower), accessed at http://www.js.pentagon.mil/descriptivesum/Y2012/Navy/0603640M_3_PB_2012.pdf, p. 6.

14. Cooling.

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16. Exhibit R–2, p. 1.

17. A 10 December 1996 demonstration of reactive materials is pictured in National Academy of Sciences, *Advanced Energetics Materials,* 2004, p. 21.