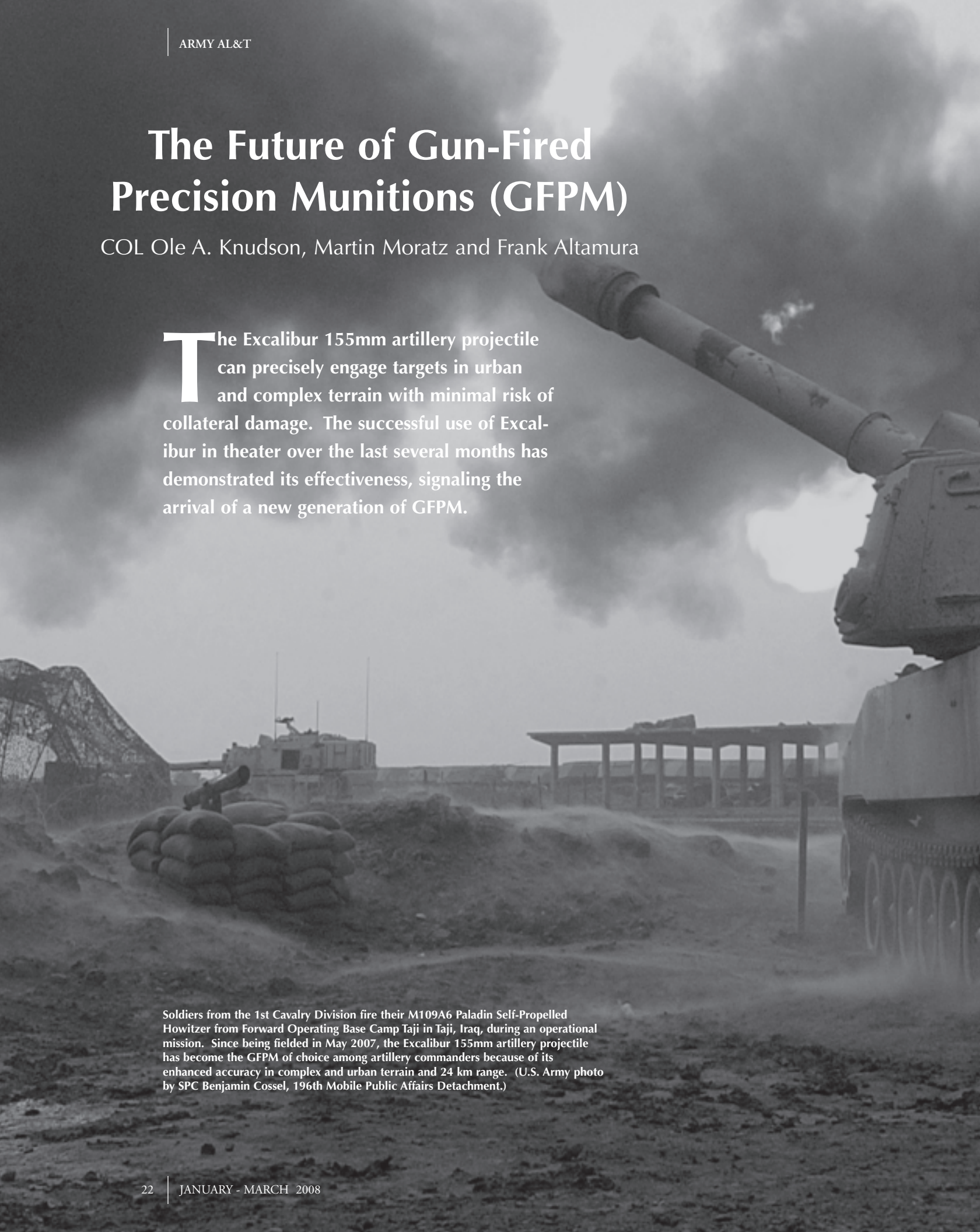
# The Future of Gun-Fired Precision Munitions (GFPM)

COL Ole A. Knudson, Martin Moratz and Frank Altamura

**The Excalibur 155mm artillery projectile can precisely engage targets in urban and complex terrain with minimal risk of collateral damage. The successful use of Excalibur in theater over the last several months has demonstrated its effectiveness, signaling the arrival of a new generation of GFPM.**



**Soldiers from the 1st Cavalry Division fire their M109A6 Paladin Self-Propelled Howitzer from Forward Operating Base Camp Taji in Taji, Iraq, during an operational mission. Since being fielded in May 2007, the Excalibur 155mm artillery projectile has become the GFPM of choice among artillery commanders because of its enhanced accuracy in complex and urban terrain and 24 km range. (U.S. Army photo by SPC Benjamin Cossel, 196th Mobile Public Affairs Detachment.)**

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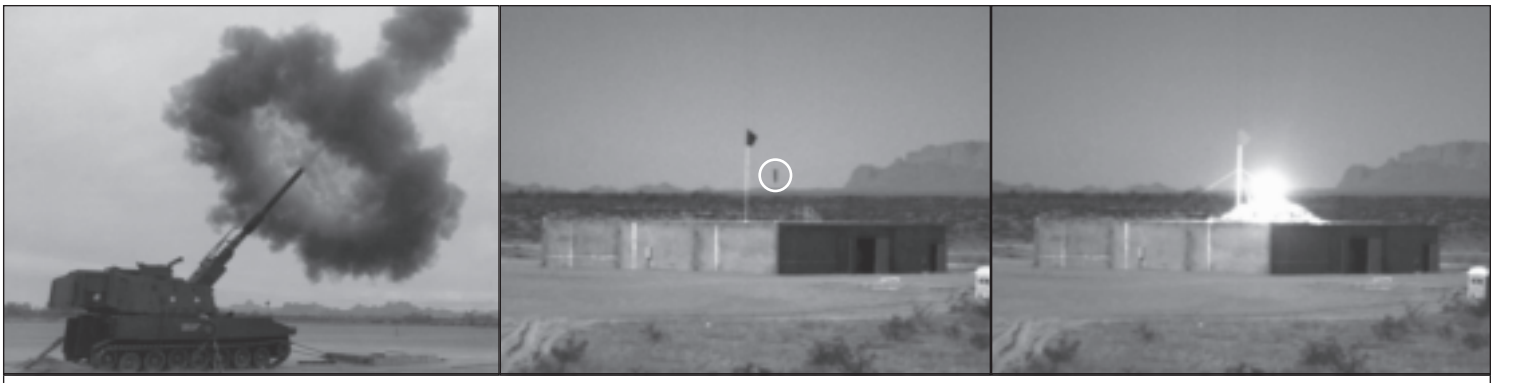
This ground-launched munition can be quickly employed without extensive mission planning or the extensive coordination needed to deliver precision munitions via an air delivery platform. In general, providing precision fires exponentially reduces collateral damage and drives down the logistics footprint while significantly increasing operational effectiveness. The deployment of a new generation GFPM holds the prospect of providing precision munitions that are much less costly overall than current missile-based or air-dropped solutions. The technical challenges to accomplish high G load (the magnitude of the acceleration compared to gravity) survivability GFPM are being solved by current Programs of Record (PORs) such as Excalibur, Precision Guided Kit (PGK), Precision Guided Mortar Munition (PGMM) and the Mid-Range Munition (MRM).

Based on the significant progress that has already been demonstrated for GFPM, one of the greatest challenges remaining is to develop more affordable solutions. Near-term solutions to make GFPM much more affordable should change the ongoing debate from "how much precision can we afford?" to "how do we implement more affordable precision solutions?" This change will ensure that the warfighter's precision needs aren't restricted by budget shortages. To achieve greater affordability, component costs must be reduced and technologies that will enable cost drivers such as inertial measurement units, semiactive laser seekers, canard actuation systems, power supplies, and fuze safe and arm devices must be further developed and simplified.

Advances in these key technology areas, coupled with aggressive acquisition strategies that maximize competition and provide participants incentives to bring forward the most cost-effective solutions, will continue to drive down the cost of GFPM. For example, PGK's Increment 1 average unit cost is approximately $3,000, making it much more affordable than any previous precision capability. Tech base and contractor's independent research and development funding focused on exploring potential solutions for artillery precision-guided munitions, and mortar guidance kits (similar to PGK for mortars) also show potential for having very affordable gun-fired precision solutions in the near future.

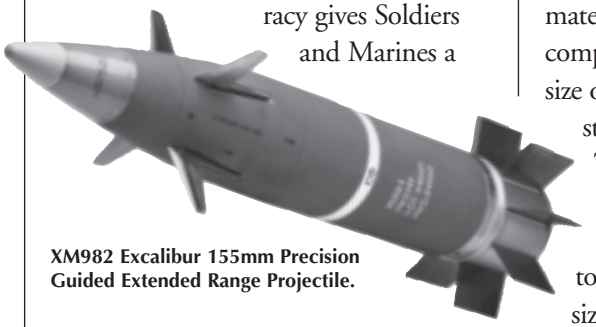
## Excalibur Provides New Capabilities in Urban Warfare

After completing development testing and a limited user test, Excalibur was fielded in May 2007 and is providing deployed forces an urgently needed 155mm artillery precision capability. The weapon's guidance system enables a fire-and-forget, continuously guided,



**An M109A6 Paladin Self-Propelled Howitzer test fires an XM982 Excalibur 155mm projectile downrange at Yuma Proving Ground, AZ. The Excalibur's on-board guidance system will deliver the projectile within a 10-m CEP accuracy with a near-vertical, terminal angle, top-attack effects capability as demonstrated in this firing sequence. The Excalibur's increased accuracy also helps minimize potential collateral damage and civilian casualties when employed against point and high-payoff targets. (U.S. Army photo courtesy of PM CAS.)**

gliding projectile with less than 10-meter (m) circular error probability (CEP) accuracy with a near-vertical, terminal angle, top-attack effects capability. Excalibur has a high-explosive (HE) warhead with three fuzing modes — point detonating, proximity and delay — that makes it effective against a variety of target types, ranging from personnel to structures and both lightly armored and other vehicles. In comparison to conventional unguided artillery projectiles, Excalibur's accuracy gives Soldiers and Marines a whole new capability that they can employ effectively in complex and urban terrain where collateral damage is a primary concern. The fielded version of Excalibur has a range of 24 kilometers (kms). A longer-range version that will reach 35-40 kms is undergoing testing and is expected to be in production soon. Raytheon is the prime contractor for the first two increments of Excalibur, and a competition is planned for follow-on increments to help reduce unit costs and increase reliability for the long term.



**XM982 Excalibur 155mm Precision Guided Extended Range Projectile.**

## PGK Solves Long-Standing Problem

The PGK will provide the Army's current inventory of 155mm HE projectiles with less than a 50-m CEP. Potentially, it will provide increased precision to a CEP under 30 m. Using a screw-on kit in place of a standard artillery fuze, PGK provides a solution to a very difficult problem: guiding an artillery projectile that has a spin rate of 250-300 hertz, weighs approximately 100 pounds and is being fired at a maximum of approximately 15,000 G loads with all the kit's components packaged in a very small size of the fuze well on the existing stockpile of 155mm HE projectiles. To greatly reduce the technical difficulty, Increment 1 requirements allowed potential technical solutions to deviate from the standard NATO size factor and use all of the space within the deep well cavity on existing HE projectiles. External stakes and canards were also allowed as long as the solutions were compatible with existing ammunition and howitzers.

The average low-rate initial production cost for the PGK is about $3,000 per unit. The simplicity of the design approach that expanded the allowable space beyond the standard fuze size was a major factor in developing a successful technical solution and in keeping the unit cost down. Alliant Techsystems, the winning contractor from the competitive technology demonstration (TD), used predeployed, fixed canards to reduce the design complexity and demonstrate dramatic improvements in first-round accuracy at longer ranges. The same TD proved that algorithms that measure antenna strength as the round spins can be used to determine roll rate and provide an accurate measurement of up, thus, eliminating the need for more complex inertial sensors. Continued competition among key component providers and other producibility improvements could potentially reduce PGK's unit cost even more. A planned follow-on competitive PGK effort will provide a similar capability for 105mm projectiles.

## XM395 PGMM — A Commander's Hip-Pocket Munition

PGMM is a multipurpose, laser-guided 120mm mortar cartridge that is capable of engaging high-payoff targets out to a maximum range of 7,200 m, providing a precision strike round capability with a first round defeat of high-value point targets such as enemy personnel protected by brick over block walls, lightly armored vehicles, earth and timber bunkers, and command and control centers. The ability to hit point targets is especially valuable in urban environments and low intensity conflicts where avoiding collateral damage and reducing the potential for civilian casualties

is critical. PGMM is fired much like any standard mortar cartridge after programming the fuze with time-of-flight, target type and laser code of the day. It can be fired from all current and future smooth-bore 120mm mortar weapons and flies ballistically to its search area where the laser sensor acquires the target. It requires an operational lasing time of approximately 10 seconds. The current PGMM engages stationary targets, and future increments will include moving targets and a longer range. The PGMM is the battalion or task force commander's hip-pocket precision munition.

## XM1111 MRM Raises Standoff, Lowers Collateral Damage

The MRM is a 120mm multipurpose, GFPM that enables the Future Combat Systems Mounted Combat Systems (MCS) to engage moving or stationary high-payoff targets at beyond-line-of-sight (BLOS) ranges from 2 km out to 12,000 m and beyond. This enables the MCS to exploit terrain and range to provide the tactical standoff that enables them to act first, as well as an organic BLOS capability, without the need to queue fires. The MCS can fire MRM while stationary or on the move, providing precision defeat of single point, high-payoff targets, including stationary or moving main battle tanks, light armor, self-propelled howitzers, air defense artillery and bunkers. MRM is compatible with the M256 gun tube, which will potentially allow for future integration onto the Abrams M1A2 tank.

The MRM employs three modes of operation: autonomous, designate and designate-only. In the *autonomous* mode, the MRM searches for and engages targets using data downloaded to the projectile prior to firing to aid in target acquisition. *Designate* is when the munition searches for a semiactive laser designator return from the target and engages it. The munition switches to the autonomous mode in the terminal phase, which allows for sensor-fuzed, aimpoint refinement to maximize lethality. If the laser spot is lost or not present, the projectile will automatically revert to autonomous. The *designate-only* mode is the same as designate, except the munition does not revert to the autonomous mode if the laser spot is lost or not present. This allows for added control where fratricide or collateral damage is a concern.

## The Key to Greater Affordability — Technology Advancement

In addition to the PORs described above, numerous technologies must be advanced to enable more affordable GFPM. Warhead technologies that will allow increased or selected lethality with a significant decrease in payload size are needed, as well as reduced rate sensors that lower cost without sacrificing performance. Introducing more Micro-Electro Mechanical Systems technology into the sensors and fuze safe and arm devices to reduce volume without degrading performance is a near-term solution to reduce costs. Developing small, low-cost, gun-hardened actuators and power supply alternatives are also essential to overall cost reductions for GFPM solutions.

To promote the independent advancement of key technologies, the Defense Ordnance Technology Consortium issued Request for Project Proposals for Very Affordable Precision and Enabling Technologies in FY07 and FY08. The enabling technologies include fuze safe and arm, semiactive lasers, height of burst sensors, super capacitors, inertial measurement units, novel actuation mechanisms, alternate energy sources, common telemetry and novel sensors. More than 25 qualifying proposals were received. These are being prioritized and, when possible, funded.

Providing affordable precision solutions to the warfighter is a clear necessity for ongoing combat operations and is likely to be essential for success in any future conflict. As technology and the current PORs advance, affordable precision will advance as well, providing dramatic improvements in precision-striking power immediately available to ground combat commanders.

**COL OLE A. KNUDSON** is the Project Manager Combat Ammunition Systems (PM CAS). He holds a B.S. in engineering from the U.S. Military Academy and an M.S. in mechanical engineering from the Naval Postgraduate School. Knudson is a graduate of the U.S. Army Command and General Staff College, the Defense Systems Management College Harvard Fellowship for Management Development and the Army War College Fellowship Program at the University of Texas. Additionally, he is a Defense Systems Management College Program Management Course and Executive Program Management Course graduate. Knudson is an Army Acquisition Corps (AAC) officer Level III certified in program management.

**MARTIN MORATZ** is the Chief, Advanced System Division, PM CAS. He holds a B.S. in engineering from the U.S. Military Academy. Moratz is an AAC member with Level III certification in manufacturing, production and quality assurance.

**FRANK ALTAMURA** is the Program Management Integration Process Team Lead for the MRM program. He has a B.S. in mechanical engineering from the New Jersey Institute of Technology and an M.S. in integrated engineering from the Stevens Institute of Technology. Altamura is certified Level III in systems planning, research, development and engineering, and Level II in program management. He is also an AAC member.