

Military technology

Artillery in the digital age

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The digital age has brought about profound changes in long established areas of weapons technology, and artillery is no exception, with digital technology now penetrating into guided artillery rounds and navigation systems in self propelled artillery pieces. A key milestone was the first operational use of the M982 Excalibur guided artillery round in Iraq during 2007.

While laser guided artillery rounds have been in use for decades, newer satellite aided inertially guided rounds offer much more flexibility and genuine all weather operations. Guided artillery rounds, range-extending munitions designs, and advanced navigation equipment have reinvigorated artillery capability, which prior to the post-2001 global counter-insurgency campaign was slowly stagnating.

The advent of advanced guided artillery ammunition fundamentally changes how artillery is used, and indeed when it can be used.

For decades, artillery pieces could be divided into precise direct fire weapons, such as anti-tank, anti-aircraft and infantry support assault guns along with indirect fire howitzers used to bombard opposing positions from standoff ranges. This division remains although direct fire weapons have increasingly been displaced by modern tank guns or larger calibre weapons on armoured fighting vehicles.

Indirect fire weapons, primarily howitzers, dominated artillery through the latter Cold War period but were challenged to compete against aerial bombs delivered by fixed wing aircraft. The niche occupied by these guns contracted to that of sustained area bombardment, as guns could not compete with the raw firepower of bombers, or the precision of aerial smart bombs. A good comparison is that a standard Mk.82 or FAB-250 500 lb class bomb, with around 90 kg of Tritonal or H-6 filler, is effectively five times the weight of a typical 155 mm artillery shell, and it is fifteen times the weight of a typical 105 mm shell. Sustained counter-insurgency operations since 2001 have however shifted the goalposts, with the imperatives of high precision and low collateral damage rising well above the traditional imperative of raw lethality against hardened targets. Insurgents in mud brick urban areas present entirely unique challenges, in comparison with the annihilation of hostile, armoured manoeuvre forces.

Earlier conflicts when air power was not a major factor, such as the various interventions and insurgencies in Africa, required frequent use of long range artillery pieces. Budgetary pressures of sustained low intensity insurgencies are now a contributing factor in the revival of artillery, as deploying and crewing a long-range gun is cheaper than delivering the same limited volume of fire by manned or remotely piloted aircraft.

Two major trends evident today are the impact of guided artillery rounds, and the impact of high mobility self-propelled guns.



Cancelled NLOS-C gun trial shot.



Laser guided M712 Copperhead approaching its target in 1986.



The M982 Excalibur was first used in Iraq, in 2007.

GUIDED ARTILLERY ROUNDS

The laser-guided artillery round emerged during the latter Cold War and remains both in use and in production. These weapons are modelled on the second generation of laser-guided bombs, employing a gimballed proportional navigation semi-active laser homing seeker.

In operation, a forward observer would point a laser designator device at the intended target and illuminate it with a pulse-coded laser beam. The supporting battery is then called to fire a laser-guided round programmed to the same code. This weapon flies most of its trajectory along a ballistic path like an unguided round, but activates its seeker and acquires the laser spot as it nears the target. The laser guided round then flies a trajectory to impact the illuminated laser spot.

Marketed as a panacea weapon during the late 1980s, in practice laser-guided artillery rounds did not live up to expectations. Under clear sky conditions they usually performed well, as the seeker had plenty of time to detect and track the blinking laser spot and effect guidance corrections to hit where intended. Under adverse weather conditions the laser seeker would be blind to the laser illumination until it broke through the overcast, upon which it was often challenged to both acquire and guide the munition in the remaining time of flight. The latter is much the same problem observed since the 1960s with laser-guided bombs dropped by aircraft.

The US-built 155 mm Cannon-Launched Guided Projectile (CLGP) M712 Copperhead remains in use. 20,000 were built until 1990, and the Russians continue to build and market the 152 mm and 155 mm variants of the KBP 2K25 Krasnopol series. KBP will ship the Krasnopol with Russian or Western laser pulse-code compatible seekers. It is also manufacturing the 122 mm Kitolov 2M laser guided round, and the Gran 120 mm smoothbore laser guided mortar round.

The US XM395 120 mm Precision Guided Mortar Munition (PGMM) program to develop a laser-guided weapon like the Gran for use in 120 mm mortars was cancelled in 2007 at the same time as Alliant Techsystems demonstrated a working prototype.

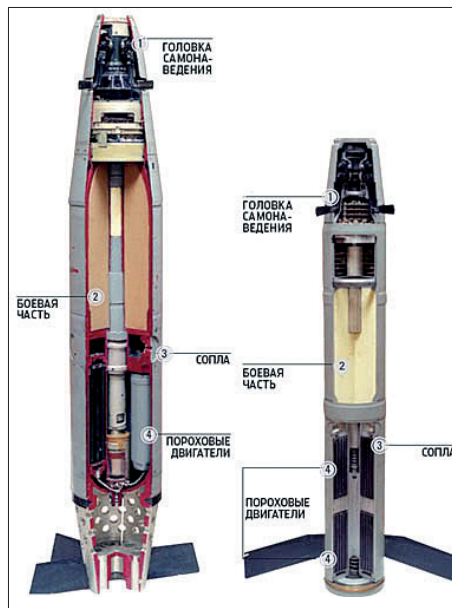
While laser-guided artillery rounds never achieved the volume of production or frequency of use intended initially, they did prove that artillery could be used to deliver guided projectiles.

Since then we have seen a number of programs to develop all weather guided rounds, primarily using a combination of satellite and inertial guidance, the same basic technology which has proved so successful in the US Air Force's GBU-31/32/35/38 JDAM and GBU-39/B SDB smart bombs.

All weapons with guidance are pre-programmed

with digital target coordinates before launch, they then fly to impact using the inertial measurement unit. A GPS, Glonass, Galileo or other satellite receiver is used to update the guidance system with accurate position and velocity information in flight. Accuracy is primarily limited by the aerodynamic and control system design and the type of satellite navigation technology used. While 'smart bombs' with wide area differential GPS have achieved miss distances under two metres, to date most cited accuracy figures for guided artillery have been much less dramatic. Figures for the M982 Excalibur are around 4.5 metres.

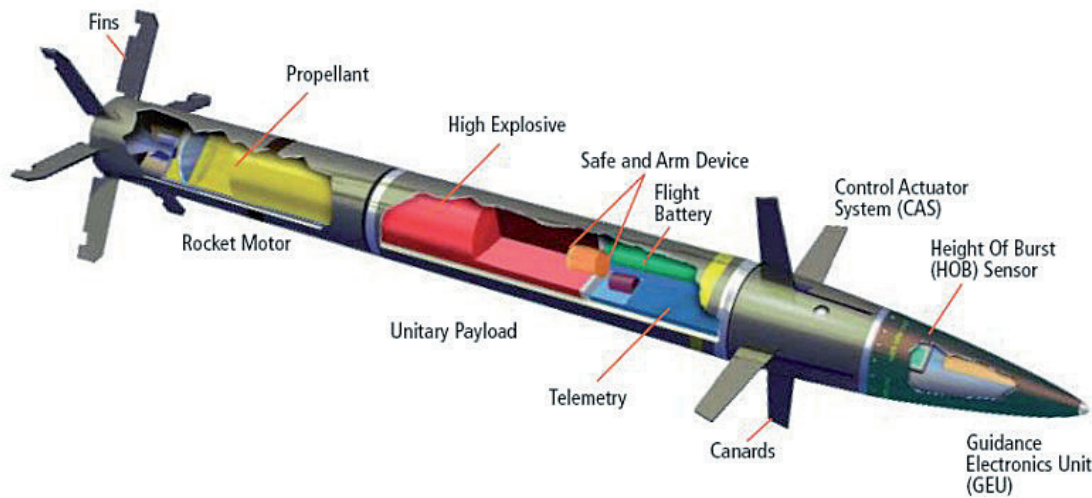
Compared to laser guidance, satellite inertial guidance offers the advantage of being oblivious to weather and visibility conditions, but also has the advantage of permitting optimal trajectory corrections mid-flight to maximise the range of the projectile, given the technology in the basic munition. Disadvantages include an inability to engage fixed targets unless the munition is fitted with a radio uplink to receive coordinate updates,



KBP based in Tula manufacture a range of laser guided artillery and 120 mm mortar rounds.

ERGM Specifications

Length:	5.1 ft	1.55 m
Diameter:	5.0 in	127 mm
Range Max:	41 nm	76 km
Weight:	110 lb	50 kg



The cancelled US Navy Mk.171 ERGM was intended for use in standard naval 5 inch guns, to provide a 120 km range guided round.

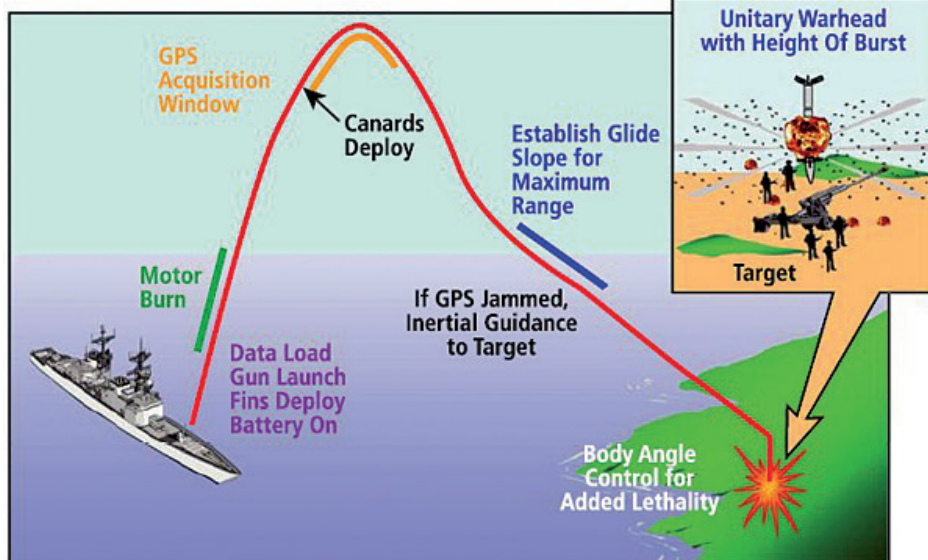
and potential vulnerability to jamming of the satellite signal. While the latter are almost irrelevant in counter-insurgency operations, they are highly relevant when the opponent is a technologically competent nation state.

The first such munition to be used operationally is the US 155 mm M982 Excalibur, the result of a US-led effort merging with the Swedish Bofors Trajectory Correctable Munition (TCM) program. The M982 is an entirely new munition design, with a modular payload bay capable of carrying a range of warheads - it exploits payload and basebleed technology developed for the M864 DPICM unguided round.

The M982 will use a Raytheon TI Systems GPS/inertial guidance package that provides a circa 10-metre CEP at range in excess of 30km. The Excalibur uses a free spinning tail and cruciform canard controls, with the weapon body containing either a unitary warhead, 64 x XM85 DPICM submunitions, or two SADARM smart submunitions. Low Rate Initial Production for all three variants will total 17,450 rounds, with up to 250,000 rounds of production expected.

While the M982 occupies the top niche in capabilities the low end is being filled with a cheaper and less capable alternative - add-on guidance kits for conventional 155 mm rounds. In 2006, the US Army initiated an effort to demonstrate and develop the XM1156 Precision Guidance Kit (PGK), a low cost GPS/inertial guidance kit that fits into the nose fuse well of a conventional 155 mm artillery round, providing both fusing and guidance capabilities. Alliant Techsystems and Interstate Electronics were contracted to develop the kit after a competitive demonstration.

The US Navy has long sought a GPS/inertial guided artillery round for naval 5-inch guns, primarily to provide fire support during amphibious or special forces operations. The Raytheon EX-171/Mk.171 Extended Range Guided Munition (ERGM) was



Operational Concept.

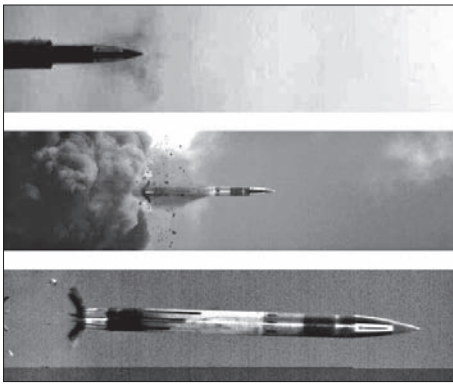
cancelled after more than a decade of development. The rocket assisted round was to have provided a range of up to 120 km, or 65 nautical miles. Lesser range was sought in two development programs, both of which were terminated - the Autonomous Naval Support Round (ANSR) and later Ballistic Trajectory Extended Range Munition (BTERM).

In parallel with these 5-inch gun programs, the US Navy was also developing a 155 mm round, the 74 nautical mile range LM Long-Range Land Attack Projectile (LRLAP) intended for the Advanced Gun System (AGS) on the DD(X)/DDG-2000 class ships. The status of the program is unclear after heavy cuts to the DD(X) program.

This US effort has been paralleled in the EU. Oto Melara in Italy has been developing a new 5-inch naval gun round family named the 'Vulcano' comprising unguided and terminally guided variants. Two guidance packages are in development. The GPS/inertial guidance package is intended for shore bombardment, and is similar in concept to US designs. An infrared seeker is in development for attacks on surface combatants. The latter would provide 5-inch gun equipped

frigates and destroyers with a capability to cheaply engage low value surface targets - including patrol boats, speed boats and other targets traditionally difficult for gun attacks, but seldom justifying the use of expensive anti-ship cruise missiles.

In France, a consortium was formed in 2004 to develop the Munition de Précision à Portée Accrue (MPPA) guided round, intended to provide a near precision capability to 80 km range. Four years ago the French tested an alternate scheme under the Spacido (Système à Précision Améliorée par Cinémomètre Doppler) program. A radar measured the trajectory of the fired round and a radio link used to deploy an airbrake to shape the trajectory. The IOCs for many of the guided munitions currently in development remain unclear, in a large part due to ongoing development funding starvation in the US, UK and other Western nations involved in the ongoing counter-insurgency effort. What is abundantly clear is that 'Pandora's Box' has been opened and guided artillery rounds are here to stay. It is this technology that has effectively stimulated a shift way from towed artillery pieces to self-propelled guns.



The 140 km range LRLAP was developed for the 6 inch gun in the DDX destroyer.

MOBILITY

Self-propelled guns first emerged in large numbers during the 1940s, and have continued in production. The classical SP-gun was a howitzer intended primarily to provide artillery support for fast moving armoured manoeuvre groups.

The Cold War brought progressive improvements in gun design, and the invention by the ill fated Dr Gerard Bull of basebleed ammunition intended to improve gun range, followed by rocket assisted projectile technology (RAP). As a result the reach of towed and fixed artillery pieces continued to improve.

The late Cold War introduced two important technologies in artillery. The first of these was the Counter-Battery Radar (CBR) designed to rapidly locate an opposing battery by tracking the projectiles in flight and computing the location from where they were fired. CBR is now widely available, and a Chinese clone of the US AN/TPQ-36 Firefinder is now available at very low cost in the Third World export market.

The second technology was the installation of Inertial Navigation Systems in SP guns, a British advancement rapidly copied by all other nations. With proliferating CBR technology, SP-gun batteries had to be able to 'shoot and scoot' to evade CBR directed counter-battery fires.

At the end of the Cold War there was a strong slump in funding for artillery, and heavy land force elements in general, which has not changed.

Artillery has however seen a renaissance of sorts, with its use in COIN operations, where the weight of fire does not justify calling in air support, or



GIAT Caesar self-propelled 155 mm gun.

where air support is difficult to secure. This in turn is why investment increased post 2001.

The combination of guided artillery munitions and CBR technology presents a major challenge for 'conventional' artillery, as towed guns in particular are exposed due to the greater time to deploy and stow, and the absence of protection for the gun crew. Towed artillery pieces will not vanish but will shift into niches such as COIN or rapidly deployable lightweight weapons, which can be redeployed by helicopter easily.

The focus in the indirect fire gun market is now firmly on self-propelled guns, and there are two parallel trends. One is the retrofit and upgrading of legacy SP gun systems, such as the widely used M109 Palladin series and its Soviet analogues. Such retrofits typically see fire control system enhancements but, importantly, satellite navigation systems, moving map displays and digital interfaces to permit a high level of automation.

The second trend is the development of entirely new SP gun systems on armoured tracked chassis, armoured or hardened wheeled chassis, and most recently on high mobility trucks. The Giat Caesar and Bofors Archer series are prime examples of the latter.

A typical modern or upgraded SP gun system will combine long range guided and unguided munitions, a gun often with a multiple round autoloader, and a sophisticated digital fire control system. The latter will typically use satellite navigation, a digital moving map, and will be equipped with datalink interfaces to accept targeting data from a CBR – or other sources. The system will be designed from the outset for a 'shoot and scoot' regime, where a magazine load of rounds are fired as quickly as possible, upon which the SP gun stows and scoots to its next location.

Longer term trends are now well established. Guided artillery rounds will follow much the same path as aerial bombs, with the first generation of satellite/inertial guidance followed by further enhanced derivatives with laser, millimetric wave radar and optical correlator seekers added to the core guidance package. Past attempts to integrate such seekers without the inertial system were not as successful as hoped for.

The imperative in SP gun systems will be mobility and increasingly hardness where mobility is insufficient to defeat an opponent's targeting cycle. Navigation and fire control systems will see increasing levels of integration and networking to accept sensor inputs.



BAE/Bofors FH77 BW L52 Archer self-propelled 155 mm gun – the magazine carries 20 ready to fire rounds.

