

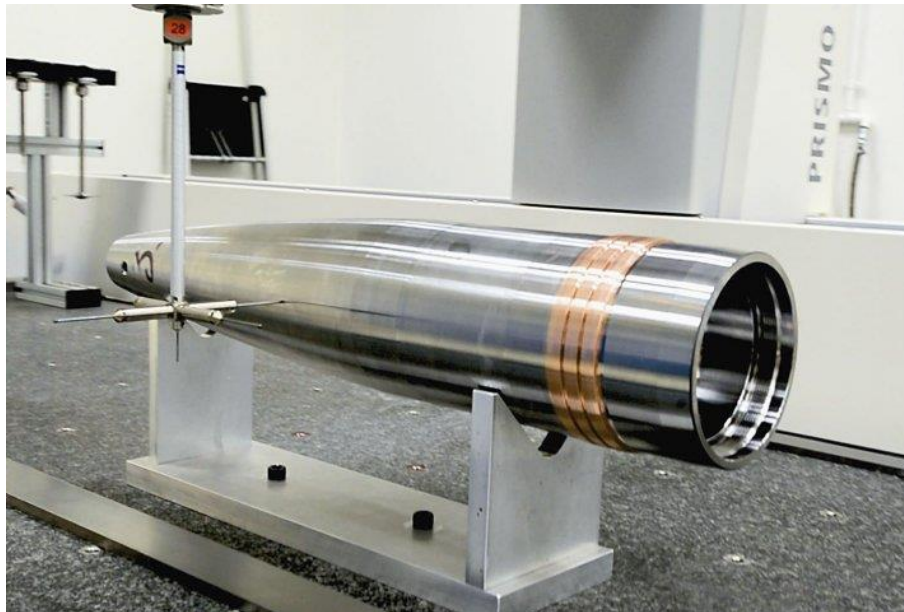
## Jane's Defence Weekly

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## Smart ammo: precision-guided munitions for field artillery

**Field artillery is increasingly employing precision-guided munitions in order to engage targets with greater accuracy. Christopher F Foss reports**

While fixed- and rotary-wing aircraft have been able to launch precision-guided munitions (PGMs) for many years, land forces have been much slower in obtaining this capability. This is beginning to change, however, with field artillery - including towed and self-propelled (SP) guns and howitzers, as well as artillery rocket systems - now starting to deploy munitions with a PGM capability.



*The new Nammo 155 mm HE-ER artillery projectile is machined inside and outside to enhance accuracy. (Nammo)*

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There is also an increasing emphasis on the development and fielding of add-on precision guidance kits (PGKs) to conventional artillery projectiles to reduce their circular error of probability (CEP).

Conventional natures of ammunition can be manufactured with much tighter tolerance, resulting in greater accuracy. A good example is Norwegian manufacturer Nammo's new 155 mm high-explosive (HE) projectile, which is designed to provide field artillery with a significant increase in accuracy over the US-designed 155 mm M107 round. Nammo's HE Extended-Range (HE-ER) projectile has been in development since February 2013 under a contract from the Norwegian Army, with Nammo also providing some of the finance.

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The projectile has a more streamlined shape than conventional 155 mm artillery rounds, thus reducing drag and increasing range. Traditionally, 155 mm artillery projectiles have been forged - which remains the first step in this manufacturing process - but the new Nammo projectile is then machined outside and inside before nosing. Machining is more precise than is possible from forging and also reduces weight and run-out variation. Another benefit from adding this extra step and manufacturing to within such strict tolerances is a reduction in dispersion when compared with traditional 155 mm projectiles.

Using a 155 mm/39-calibre ordnance, trials have shown that at a range of 20 km and using the Rheinmetall DM72 modular charge system with five modules, Nammo's 155 mm HE-ER projectile has a deviation of +/- 30 m from target. For the Nammo NM28 - which is its version of the US-developed M107 HE projectile - this figure is +/-80 m.

In addition to having improved accuracy, the HE-ER projectile also has an enhanced fragmentation effect against a wide range of battlefield targets.

It has a modular design fitted with a screw-on interchangeable base-bleed (BB) unit to achieve increased ranges. This is used as an alternative to the screw-on, hollow-base unit, used for short and medium ranges.

Another 155 mm artillery projectile featuring a more streamlined design is the extended-range, full-bore, BB projectile manufactured by South Africa's Rheinmetall Denel Munitions.



*The Rheinmetall Denel Munitions 155 mm V-LAP HE projectile has a streamlined shape and features BB and*

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rocket assist to provide an extended range. (Christopher F Foss)

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### **Laser-guided projectiles**

The US Army first fielded the 155 mm Copperhead laser-guided projectile (LGP) many years ago, but China and Russia have more recently developed LGPs that typically enable targets to be engaged at a range of around 20 km, although this does depend on prevailing conditions and the use of forward observers.

LGPs do suffer from a number of tactical disadvantages: the forward observer has to 'paint' the target throughout the whole engagement process; bad weather and terrain conditions can make target acquisition and designation difficult; and engaging moving targets can also be problematic as they can move out of line of sight. Further, AFVs are now being fitted with laser warning receivers that alert the crew as to whether they have been detected by a laser rangefinder, LGP, or laser-guided anti-tank guided weapon. Nevertheless, LGPs have been successfully used in combat by both India (the Russian 155 mm Krasnopol) and the United States (the now very old Copperhead round).

The Russian Army is the largest user of LGPs and a number of these have been developed under the leadership of the KBP Instrument Design Bureau.

KBP's 152 mm Krasnopol is fired from the 152 mm 2S19 SP artillery system and some towed artillery systems. It is fitted with an HE fragmentation (HE-FRAG) warhead and has a typical range of about 20 km. When in flight four fins unfold at the rear, with the control surfaces sited towards the front. It is used in conjunction with the tripod-mounted ID22 laser target designator/rangefinder (LTD/R) and at 20 km hit probability is claimed to be between 70 and 80%. The 155 mm version developed for export is known as the Krasnopol-M.

Also in production is the 122 mm Kitolov-2M LGP. This can be fired from 122 mm systems such as the widely deployed D-30 towed weapon and the 2S1 SP system. This is also fitted with an HE-FRAG warhead and has a maximum range of 20 km with a claimed 80% hit probability.

In recent years China has developed complete families of new ammunition for 122 mm and 155 mm weapons. This has followed Russian attempts to move to the NATO 155 mm calibre to sustain its export potential.



A Chinese 122 mm GP5 laser-homing artillery weapon system as the projectile would appear during part of its flight to the target. (Norinco)

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At least two 155 mm LGPs, designated the GP1 and GP6, are being marketed by China's Norinco. The GP1 has a maximum range of 20 km and a claimed hit probability of 90%. The GP6 increases the range to 25 km and is claimed to be more difficult to jam. It also features multiple-laser coding technology that enables cooperative multi-target engagements.

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*A full-scale model of the 155 mm version of Ukraine's Kvitnyk-E LGP with extended control surfaces at the front and four fins at the rear. (Christopher F Foss)*

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### **Excalibur: combat-proven**

The most significant Western purpose-designed guided artillery projectile on the market is the 155 mm M982 Excalibur (a joint project between Raytheon and BAE Systems Bofors), which costs in the region of five times as much as a PGK-equipped shell but officially has a CEP of about 5 m (in practice it is said to commonly strike within 2 m of the target). As a result, US forces prefer the Excalibur where high precision is required.

Excalibur is an extended-range, autonomously guided projectile using a combination of high-glide-ratio, lifting-body airframe and tightly coupled GPS/inertial measuring unit (GPS/IMU) guidance to achieve ranges of up to 37.5 km with a high degree of precision from both the US Army's M109A6 Paladin SP gun and 155 mm/39-calibre M777 towed artillery system.



*The earlier Excalibur Ia round (left) compared with the more recent Ib version, which has a redesigned rear section with integral BB unit for longer range and forward-folding fins. (Scott Gourley)*

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The M982 programme encompasses a family of three projectiles, differing in their respective payloads. Increment Ia.1 carries a unitary penetrating warhead; Increment Ia.2 increases the range from 24 km to

37.5 km; and Increment Ib aims to maintain performance and capabilities while reducing unit cost and increasing reliability. As of June 2014 production runs of the Ia.2 variant have been completed.

In mid-2014 Raytheon received approval for full-rate production of the Excalibur Ib and a USD52 million contract for continued Ib production. Increment Ib deliveries are to run until fiscal year 2017.

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### **Oto Melara develops Vulcano family**

With sponsorship from the Italian Ministry of Defence, Oto Melara is developing the Vulcano family of 155 mm ballistic extended-range (BER) and guided long-range (GLR) projectiles, as well as 76 mm and 127 mm naval munitions.

The Vulcano projectile is of the sub-calibre type and loaded with insensitive munitions (IM)-compliant explosive and patented tungsten rings.

The BER, which has been qualified and is under low-rate initial production, is an unguided 155 mm artillery projectile with a multifunction fuze (height, impact, delayed impact, time, and self-destruct) and a range of up to 50 km.

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### **PGK: a cost-effective alternative**



*The Orbital ATK Armament Systems M1156 PGK can be fitted to 155 mm artillery projectiles to give a significant improvement in accuracy. (Orbital ATK Armament Systems)*

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An add-on PGK is a cost-effective way of improving the accuracy of artillery projectiles. The first of these to enter production was what is now called the Orbital ATK M1156. The PGK is built around a fuze system and upgrades conventional 155 mm rounds into a GPS-guided weapon. It is less expensive than the Excalibur GPS-guided round but not as accurate.

ATK Armament Systems won a competitive shoot-out in 2009 against BAE Systems in order to move its PGK into the system development and demonstration contract. PGKs were first delivered to the US Army under an urgent material release in 2013 for use on 155 mm M549A1 and M795 HE artillery projectiles in Afghanistan. The kits are installed on the projectiles by simply fixing them into the fuze well. The PGK can then alter the munition's trajectory towards a specific target location and can be point-detonated or proximity-detonated (or enter a 'fail-safe' mode if it does not come close enough to the prescribed target).



*A BAE Systems 155 mm/39-calibre M777 series artillery system carrying out a fire mission with a 155 mm HE projectile (right) fitted with Orbital ATK Armament Systems' M1156 PGK. (Orbital ATK)*

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Low-rate initial production of the M1156 began in early 2014 and was followed by a full-rate production contract award worth USD120 million in May 2015. Some 12,000 units have now been completed.

The army's total requirement is for more than 100,000 PGKs. Deliveries are scheduled to run from early 2016 through to early 2018 for the US Army, US Marine Corps, Australian Army, and Canadian Army.

During its first lot acceptance testing in April this year, the M1156 demonstrated median accuracy of less than 10 m with a reliability of 97% when fired from the 155 mm/39-calibre M109A6 Paladin.

While the US Army uses the M1156 PGK with 155 mm/39-calibre M109A6 SP and M777 towed-artillery systems, it has already been successfully fired from a number of other 155 mm artillery systems, including the PzH 2000, G6, K9 Thunder, ATMOS, AS90, and CAESAR, with the first export customers being Australia and Canada.

"The PGK approach is a mature technology that, when applied to existing, indirect-fire missions, has the ability to greatly increase accuracy and effectiveness of conventional stockpiles," said Dan Olson, vice-president and general manager of Orbital ATK Armament Systems Division.



"In this case, for 155 mm artillery projectiles, we have now proven this technology's performance, reliability, and safety during rigorous acceptance testing that has consistently shown a median accuracy of less than 10 m," he added. "We have also seen 5 m accuracy during testing with the PzH 2000 earlier this year."

BAE Systems Rokar of Israel is marketing its Silver Bullet GPS-based PGK for 155 mm artillery projectiles for international customers.



*The BAE Systems Rokar Silver Bullet PGK is designed to be rapidly fitted to standard 155 mm artillery projectiles. (IHS/Patrick Allen)*

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The Silver Bullet, which has been in development since 1997, is attached to a 155 mm projectile as a screw-in fuze on the nose, changing a conventional round into a PGM that can be programmed through a radio-frequency link and then directed towards a target by two pairs of canards.

During initial firing trials carried out in southern Israel's Negev Desert using a 155 mm/52-calibre system, a CEP of less than 10 m was achieved. Over the last several years more than 150 155 mm Silver Bullet PGKs have been tested, with some of these achieving a CEP of less than 4 m.

The Israeli-developed kit is probably easier to sell internationally than US-developed systems because it is not subject to US International Traffic in Arms Regulations (ITAR). According to the company, the kit so far has been demonstrated for "several" potential customers, one of which was South Korea's Poongsan Corp.

While the most recent live-fire event took place in February, over the last several years "more than 150 Silver Bullet precision guidance kits have been tested" in various conditions and terrains, "including land and sea", said a BAE Systems Rokar spokesperson.

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### **Artillery rockets**

Until recently multiple rocket launchers (MRLs) provided the force commander with the capability to provide a massive amount of suppressive fire in a very short period of time.

The main drawback of MRLs is that, as with artillery projectiles, they become less accurate as the range increases. This has led to the fielding of rockets with a guidance system to provide greater accuracy.

The first of these to be fielded in large numbers was the Lockheed Martin Missiles & Fire Control Guided Multiple Rocket System (G-MLRS), which can be fired from the upgraded M270 series tracked launcher and the more recent M142 High-Mobility Artillery Rocket System (HIMARS).

The tracked M270 has two pods each of six 227 mm rockets, while the HIMARS has just one pack of six rockets but greater tactical and strategic mobility.

Maximum range of the original 227 mm M26 unguided rocket is 31.6 km, which compares with more than 70 km the G-MLRS used in Afghanistan by the United States and the United Kingdom, with the latter deploying upgraded M270B1 tracked launchers.



*Norinco's AR3 MRL with eight launch tubes for 370 mm rockets, which can include guided rockets (one of these is pictured on the left side). (Christopher F Foss)*

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With the Chinese defence industry having the widest range of MRL of any country in the world. In recent years a number of Chinese contractors have started to market rockets with guidance systems fitted for increased accuracy.

For the AR3 370 mm/300 mm MRL based on an 8x8 cross-country chassis, Norinco is already offering for export the BRE3 300 mm guided rocket with a maximum range of 130 km and the BRE6 and BRE8 370 mm guided rockets with ranges of 220 km and 280 km respectively.

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### **Guided mortar rounds**

Mortars are among the most effective weapons on the battlefield and are normally deployed by infantry on a scale of six mortars per battalion. However, in some countries mortars now come under the field artillery.

Like 155 mm artillery systems, 120 mm mortars normally fire HE, smoke, and illuminating projectiles, but there is also a trend to provide these with a precision target engagement capability.

Leveraging the design, development, and production of 155 mm, 152 mm, and 122 mm LGPs, KBP has developed a 120 mm laser-guided mortar projectile called the KM-8 Gran, which is used with the ID22 LTD/R. This has a maximum range of 9 km and is fitted with an HE-FRAG warhead.

Meanwhile, Norinco has recently entered the fray with two advanced 120 mm precision mortar systems. The first of these is the GP9 laser-guided mortar bomb, featuring control surfaces at the front and fold-out fins at the rear, that can be fired against targets from 2 to 7.5 km away. It is designed to operate in conjunction with Chinese OL1 or OL2 LTD/Rs. These have maximum designation ranges of 5 and 7 km respectively. The GP9 is claimed to be able to successfully engage targets moving at a maximum speed of up to 36 km/h and has an anti-jamming capability.

The second is the GP4: a 120 mm mortar projectile with a maximum range of 6 km. It uses the same LTD/R as the GP9 and has impulse-correction thrusters around the centre and fold-out fins at the rear.

Israel Military Industries (IMI) is developing a 120 mm guided mortar munition (GMM), which is currently being qualified for use by the Israel Defense Forces' 120 mm mortar platforms.

The brain of the 120 mm GMM is IMI's 'Pure Heart' miniature guidance system, which integrates a synchronised navigation, real-time computing and control system into a single blast-hardened guidance package.

According to IMI, the 120 mm GMM enables targets to be engaged at ranges of up to 8 km with a precision effect, with the option of air-burst or impact fuzing.

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