Artillery for the Army

precision fire with mobility

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Current unilateral strategy to harden the Australian Army, adapting fighting units to fight in the types of conflict the Land Force expects to encounter over coming decades, is imperative – and it is long overdue. An essential element of this doctrine is Project Land 17, which aims to upgrade the Army's field artillery capabilities, bringing Army capabilities to current world standard.

While Australian Army artillery batteries have significant capability, self propelled artillery combined with guided artillery rounds are now the benchmark, and represent a long overdue enhancement to ADF offensive fire capability.

Army artillery units, armed with towed artillery pieces such as the M198 155mm medium towed howitzer and the L119 105mm light towed howitzer, use these robust and proven weapons to maximum effect but towed weapons are not well suited to a rapidly moving manoeuvre force.

In assessing options for an artillery system upgrade, issues such as current tactics in artillery use, deployability, battlefield mobility, self-propelled howitzer technology and guided artillery rounds all contribute to the final decision.

Utility of Artillery

Artillery is arguably one of the oldest arms, tracing its origins to towed and transportable projectile launchers used by Roman legions two millennia ago. The advent of gunpowder enabled faster and larger projectiles to be hurled over larger distances, but the basic paradigm of a horse-towed projectile launcher remained for centuries. Trucks or tracked artillery towing vehicles replaced horses, but this model did not change until Krupp constructed the first Self Propelled Howitzer (SPH), the Sd.Kfz.165/1 using a 105 mm leFH 18/1 L/28 howitzer in a turret on a Panzer IV chassis. By the end of World War II every major power operated some type of SPH.

Artillery remains in use for a wide range of tasks on the battlefield, especially supporting advancing infantry or defensive positions. Bombardment of enemy entrenchments, hardened forward positions, staging areas, resupply sites and convoys, troops and vehicles on the move, are typically Indirect Fire roles: projectiles fired on high angle trajectories at targets beyond line of sight to the artillery piece. In Direct Fire roles the artillery piece has line of sight to the target and usually shoots along a flat trajectory. Direct Fire is used primarily in the anti-tank role or fire support for advancing infantry against hardened positions. A key role for artillery has been counter-battery fire, or bombardment of opposing artillery batteries.

Clockwise from right:
The MSTA-S 2S19, M109A6 Paladin, AS90 Braveheart and PzH 2000, are all examples of 'classical' tracked self propelled howitzers, evolved to fight the heavy land battle in the European theatre. Designed for high cross country mobility and good resilience to counter-battery fire, they are too large and heavy for airlift deployment.

Self Propelled Artillery

The use of artillery for battlefield fire support peaked during World War II on the Eastern Front where the Soviets employed it in bombardment roles, by then subsumed by air power in US, UK and German force structures. Since then, air power has progressively eaten into the roles traditionally held by field artillery. The advent of precision-guided bombs, and more recently 500lb or smaller precision bombs such as the GBU-12, GBU-38, GBU-39/40, will ultimately see the demise of classical heavy artillery pieces.

Medium and light artillery will survive longer term, since they occupy a niche below the weight of fire and projectile size of air delivered bombs, but above the range and weight of fire of man-portable or lower calibre projectile and guided weapons. A standard Mk82 500lb bomb, with 87kg of Tritonal or H-6 filler, is effectively five times the weight of a typical 155mm artillery shell, and it is fifteen times the weight of a typical 105mm shell.

Artillery continues to provide the capability for sustained harassment fire, or area fire support for infantry. This capability is useful as it is organic to the land force, and it doesn't require calling in aircraft to orbit overhead to pick off small targets or provide suppressive fire. In many situations, calling in air power amounts to 'killing a cockroach with a sledgehammer'.

There is little doubt that the classical heavy artillery bombardment role has fallen to air power, and that is unlikely to change, but the advent of precision guided artillery rounds, using semi-active laser homing, or satellite/inertial guidance, provides for a surgical capability in rounds well below the weight of air delivered bombs.

For the Australian Army, the significant long term issues with artillery capabilities lie in battlefield and strategic mobility. Australia has long centred its army capabilities in light forces, primarily optimised for the type of campaigns fought in the region since 1942. The Army is now shifting to a light armoured force model, with the M113 supplemented by the ASLAV/LAV-25 and Bushranger. This provides for much better manoeuvre capability on the battlefield, further supplemented by the planned growth in heliborne-lift capability. A by-product of this shift is that conventional towed artillery, represented by the M198 and L119 guns, will be challenged to keep up with the improved mobility of the rest of the land force.

Since World War II heavy land forces have used a wide range of tracked SP guns to provide a highly mobile artillery component for land manoeuvre forces. Very recently, wheeled light SP-guns have emerged in the market, reflecting in a large part the strategic mobility problems arising with a 45 to 60 tonne tracked SP-gun.

With six decades of history, modern SP guns reflect the evolutionary pressures observed in Europe since 1945. The model set by the Sd.Kfz.165/1 has largely remained: evolution of a tank chassis, with high cross country mobility, an armoured turret to provide crew protection from counter-battery fire, aerial attack and opposing infantry, and a gun reflecting the role of system. Early SP-guns were easily divided into three categories: light/medium/heavy howitzers for indirect fire support, light/medium short barrel howitzers for infantry direct fire support (esp in urban combat), and self-propelled anti-tank guns. The latter two categories have since vanished, with tanks absorbing the role. The first category has narrowed, as air-delivered smart bombs displaced the larger calibre guns.

There have been only three important technological advancements in SP-guns during recent decades. The first of these was the introduction of extended range projectiles, which employ additional onboard propellant to offset drag-induced loss of projectile velocity during flight, or to provide additional thrust. Second was the introduction of inertial, and later satellite aided inertial navigation equipment on the SP-gun to allow 'shoot and scoot' tactics to evade counter-battery fire, but also to avoid lengthy set up times to prepare for a fire sortie.

The third of these was the introduction of precision guided projectiles, or payloads of precision guided submunitions, adding a precision capability analogous to that seen earlier in air-delivered bombs.

Representative modern 'classical' SP gun systems differ only in detail:

* M109A6 Paladin, introduced in 1994, combat weight of 28.8 tonnes, road speed of 64km/h, inertial navigation, 155mm M284 cannon.
* MSTA-S 2S19, introduced in 1989, combat weight of 42.5 tonnes, road speed of 60km/h, 152mm 2A64 or a NATO standard 155mm gun.
* AS90 Braveheart, introduced in 1992, weight of 42 tonnes, road speed of 55km/h, Systems Laser Inertial Artillery Pointing System (LINAPS), 155mm gun.
* PzH 2000, introduced in 1998, weight 55 tonnes, road speed of 60km/h, L52 155mm gun.

The weight and size of such systems presents a genuine problem with deployability. These systems are too big and too heavy for C-130 airlift, making road/rail and sealift the only practical options. For the ADF, an SP-gun system that cannot be airlifted by C-130 is simply not a proposition.

Wheeled medium SP-gun systems emerged globally during the 1990s, the first generation reflecting unique end user needs. The best-known system in this category is the South African Denel G6 155 mm SPH, and its newer G6-52 derivative, often presented as an option for the ADF. The G6 is mounted on an Alvis OMC 6x6 wheeled chassis, but it follows the pattern of classical SPH systems, using a large turret for protection. With 85km/h road speed it has better in-theatre mobility than tracked alternatives but at a weight of 47 tonnes and width of 3.4 metres it has the same difficulties in deployability as the tracked alternatives. The other systems in this niche are of former Warpac origin.

The Czechoslovak Type 77 DANA was developed during the 1970s as an alternative to the Soviet 2S3 SPH. It uses a Warpac standard 152mm gun system in a turret on a Tatra 815 8x8 wheeled chassis. More than 750 were built by 1994 and the system remains in use in the Czech Republic, Slovakia, Poland, Libya and Russia. Weighting in at 29.5 tonnes, with a road speed of 80 km/h, the Dana is lighter than the G6 series. The Zuzana is a 1990s derivative, equipped with a 155 mm gun compatible with NATO ammunition types.

The Russian A222 Bereg 130 mm SP-gun, designed for coastal defence batteries, uses a large turreted system mounted on a MAZ-543 series 8x8 vehicle, resulting in a 44tonne package with a 60km/h road speed. Equipped with a specialised anti-ship gun and fire control system, the A222 has not been a player in the global market.

As alternatives to tracked SP-guns, the large wheeled systems offer better road speed at the expense of off-road mobility and damage resistance.

The latest evolution in SP-gun systems have been lightweight 20tonne class 155mm wheeled 6x6 systems designed for rapid deployment using C-130 or similar airlift capability. This category is clearly of most interest to Australia as they are small enough to be deployed to support both regional and global operations. Unlike heavier wheeled systems, these SPH systems lack armour and are primarily designed as road mobile indirect fire systems, with some off-road mobility. Both current production systems, the French Giat Caesar and Israeli Soltam Atmos 2000, have their origins in earlier lightweight tracked self-propelled 155mm SPH designs.

Giat Industries Caesar

The Giat Caesar (Camion Equipe dun Syste'me d'Artillerie) 155mm 52-calibre gun system was ordered by the French Army to support rapid deployment forces, replacing towed TRF1 artillery pieces. Eight batteries with 72 guns are to be re-equipped. Five pre-production Caesar systems entered operational evaluation with the French Army late last year, installed on Daimler Benz Unimog 6x6 chassis. EU sources claim production systems will be fitted to 6x6 Renault Trucks Defense chassis instead of Unimogs. The Caesar system evolved from the earlier 155mm AM F3 gun on the AMX-13 chassis.

The Caesar has been bid for the British Army Lightweight Mobile Artillery Weapon System (LIMAWS) program, with United Defense entering a marketing agreement with Giat to offer a derivative system for the US Army and Marine Corps. The US Army 18th Airborne Corps is regarded as a potential user, along with new expeditionary Brigade Combat Teams (BCT) and Marine Corp expeditionary units. The 8-tonne Oshkosh Medium Tactical Vehicle-Replacement (MTVR) is proposed as the platform. Both the Army and Marines are currently committed to the BAe Systems Land Systems M777 Ultra-lightweight Field Howitzer (UFH) program, a towed piece intended as a direct replacement for the legacy M198. In Australia, the Caesar is marketed by Australian Defence Industries.

Giat claim the Caesar is deployable by C-130 and by CH-53E heavy-lift helicopters. The basic weight of the system is 17.7 tonnes, combat weight 18.5 tonnes, and airlift configuration weight 16.2 tonnes. A design aim was to provide double the road speed of legacy-tracked systems, the Caesar cited at more than 100km/h using the 6x6 Unimog with a 240 SHP turbocharged diesel. In this configuration the system has a range of 600 km. An extended crew cabin with air conditioning can be fitted, providing for the six-person crew.

To permit 'shoot and scoot' operations the Caesar package includes a SAGEM Sigma 30 GPS/inertial navigation system and a heavily automated Thales Communications Atlas Canon fire control system, which includes a ballistic computer and a Intertechnique ROB4 muzzle velocity radar. The Fast-Hit fire control system includes an auxiliary panel on the back of the truck. Giat claim the Caesar can deploy to fire and shoot six rounds in two minutes, before relocating to evade counter-battery fire, then fire three rounds in 15 seconds, or six in one minute. The system is designed to permit gun aiming before the vehicle halts to initiate firing. A hydraulic loading tray for shells and hydraulic rammer are employed, with an automatic drum-based primer loading mechanism, with 14 primers. Sixteen ready rounds are carried.

The 155mm 52-calibre gun can be elevated up to 66 degrees and can traverse 15 degrees left or right. Giat claim a 42-km range with Extended Range Full Bore - Base Bleed (ERFB-BB) ammunition and compatibility with a range of 155 mm munition types.

The Giat Caesar is a C-130 transportable 155 mm SPH system, carried on a Unimog 6x6 chassis. Designed for rapid deployment, it achieves high road speed (Giat).

The Soltam Atmos 2000 is like the Caesar, designed for rapid deployment using the C-130. The Atmos 2000 was trialled on the Tatra 815 VVN 6x6, but is available on other chassis (Soltam).

Soltam Atmos 2000

Soltam's Atmos 2000 (SPWH 2052) is, like the Caesar, designed for rapid deployment and 'shoot and scoot' operations and it is an evolution of an earlier tracked SPH system, the Rascal, carried by a lightweight 20 tonne tracked vehicle. The Atmos 2000 is currently supplied on the Czech built Tatra 815 VVN 6X6 truck chassis, a shortbody variant of the same Tatra 815 chassis used for the Type 77 Dana/Zuzana systems. The Tatra 815 is an evolution of the Tatra 813 series 8x8 heavy truck - the choice of this platform may be a result of India's licenced production of this vehicle. Available literature indicates that Soltam will integrate the gun system on a client's chassis of choice.

At this time the only known client for the Atmos 2000 is the Romanian Army, although reports indicate the Israeli Army is trialling the system.

The Atmos 2000 is cited at 22 tonnes but is claimed to be transportable by C-130 aircraft. The basic Tatra 815 VVS is a 12.7 tonne empty weight chassis, with a 20.7 tonne gross weight, and 320 SHP engine permitting an 80km/h road speed. The system has a cited range of 1,000km by road, with provisions for a crew of six.

The system is equipped with a digital Advanced Fire and Control System, of which no further details have been disclosed. Given the availability of a range of Israeli designed GPS/inertial systems, it is safe to assume that an Atmos 2000 bid for the ADF would have such a capability.

The Atmos 2000 is offered with 155mm 39, 45 and 52-calibre barrels, and the Russian 130mm M-46 gun is also on offer. The cited range for the 52 calibre Atmos using Extended Range Full Bore Base Bleed (ERFB-BB) munitions is 41 km, using NATO L15 munitions 30 km, and legacy M107 rounds 22 km. Hydraulics drive the load assist systems, the hydraulic spades and the gun aiming drives. A firing rate of three rounds per 20 seconds, or a sustained 70 rounds per hour, are cited. The gun aiming actuators permit an elevation of 70 degrees and traverse of 25 degrees left or right. Compatibility with all NATO munition types is also claimed.

The principal issue for an ADF operated Atmos 2000 variant would be the choice of vehicle, as the 'Unimog-centric' ADF would almost certainly insist on a Unimog 6x6 variant to maintain compatibility with existing infrastructure.

In comparing the Caesar and Atmos 2000, both systems provide similar gun capabilities, similar system weight for airlift, similar on-road performance and road speed, and similar automatic loader and fire control / navigation capabilities. Therefore, a choice between the two would be contingent on issues of acquisition cost, timelines, risk, and detailed technical features such as fire control capabilities, datalink integration, and loader capabilities.

The Czech 152 mm Dana and 155 mm Zuzana are carried on a lightly armoured Tatra 815 8x8 truck, the system was exported to the Mideast and Warpac nations.

The Denel G6 is the world's largest wheeled 155 mm SPH, and is directly equivalent to the top tier tracked systems. Its size and weight preclude airlift deployment (Denel).

Extended Range Munitions

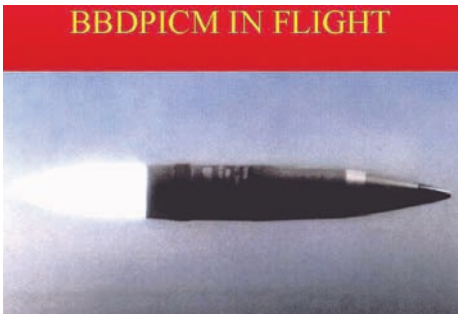
The most important development in unguided artillery munitions over recent decades has been the advent of extended range munitions, most frequently available in the 155 mm class.

Two categories are currently used, with unique techniques for extending the ballistic range of the projectile.

Base Bleed (ERFB-BB) projectiles achieve range extension by reducing the drag of the round during its ballistic trajectory. This is done by fitting the projectile with a base burner module, a canister containing a hot gas propellant which is expelled through a circular array of exhaust jets. The hot gas forms a bubble behind the projectile, which suppresses the formation of turbulent vortices behind the projectile, reducing drag. Typically this halves the aerodynamic drag force experienced by the projectile, extending range considerably. Comparing range performance for legacy rounds like the M107 against newer base-bleed munitions, for the same gun type, suggests an effective doubling of range.

Rocket Assisted Projectiles (RAP) extend range by adding a rocket propellant pack to the munition, which provides additional thrust to the munition, offsetting drag and adding to the momentum provided by the gun barrel. Cited figures for 155mm RAP munition ranges sit at around 50km, with ultimate range determined by the specific impulse of the propellant, and what fraction of the projectile mass is committed to the rocket motor.

The principal issue for unguided or dumb extended range munitions is accuracy, because increasing range inevitably exposes the round to varying cross winds and varying atmospheric density along its flight path. A doubling of range thus results in at least a doubling of the dispersion error.



Base bleed ammunition uses a hot gas generator to reduce aerodynamic drag by creating a hot gas bubble behind the weapon, suppressing turbulent flow creation. This image shows an M864 in flight (US Army).

The M982 Excalibur Precision Guided Extended Range Artillery Projectile is a 155 mm GPS/inertial guided munition with base bleed range extension, and the choice of DPICM dumb bomblet submunitions, SADARM smart submunitions, or a unitary warhead (US Army).

The M898 SADARM (Sense and Destroy Armor) is a smart submunition which uses a combination of infrared scanning and millimetric wave radar to detect targets and initiate its charge, which creates a high velocity slug for top armour attack (US Army).

It should come as no surprise therefore that a large fraction of existing 155mm extended range munitions are supplied with submunition-dispensing payloads rather than conventional unitary blast fragmentation payloads. To a large extent this reflects the reality that counter-battery fire is considered as important a role as delivering fire against other targets. Most modern artillery operators will employ counter-battery or fire-finding radars to track incoming projectiles and calculate the location of an opposing battery. With submunition payloads, counter-battery fire can be used to carpet the last known location of the opponent's battery and a near enough footprint to if possible disable or destroy the enemy's SPHs.

The US Army is a major user of submunition dispensing 155mm artillery munitions, these including the M449A1, which carries anti-personnel submunitions, the M483A1 FASCAM anti-armour and anti-personnel submunitions, the M692 ADAM anti-personnel mines, the M718A1 RAAM anti-tank mines and the extended range M864 DPICM a mix of anti-armour and anti-personnel submunitions.

The M864 Base Burn DPICM (Dual-Purpose Improved Conventional Munitions) carries a total of 48 M42 grenades and 24 M46 grenades, which have shaped charges capable of penetrating more than 2.5 inches of rolled homogeneous armour, and produce a fragmentation effect against personnel or soft targets. In practical terms this is an artillery fired equivalent to an air delivered cluster bomb, but with a smaller payload and footprint.

Precision Guided Artillery Munitions

The US Army has also been the first to deploy guided submunition-dispensing 155 mm artillery rounds. The M898 SADARM (Sense and Destroy Armor) is intended as a counter-battery weapon, carrying a pair of SADARM smart submunitions. Each submunition is deployed over the target, the submunitions dangling on drogue parachutes while using their millimetric wave and infrared dual mode seekers to detect targets. Once the target is acquired the submunition fires its charge, propelling a self-forming penetrator slug into the top of the target. The SADARM is conceptually closest to the Skeet submunition, carried by the US Air Force Sensor Fused Weapon.

Guided 155mm munitions first emerged during the 1980s, when the US invested in a large scale effort to develop technologies intended to cripple or stop large scale Soviet armoured forces in Europe.

The first such munition to enter service was the 155mm M712 Copperhead, which uses a semi-active laser homing seeker and inertial midcourse guidance.

The Cannon-Launched Guided Projectile (CLGP) M712 Copperhead weighs 137.6lb and at 54 inches length is larger than conventional 155mm rounds. It comprises a nose section with a guidance package and laser seeker, a warhead section with a shaped charge anti-tank warhead containing 14.75lb of Composition B HE, and a aft control section with wings and steerable tail.

The Copperhead is fired like a conventional ballistic round, and flies to the apex of its trajectory along a ballistic arc. An internal timer, programmed before launch, is then used to activate the guidance package, which uses an inertial autopilot to maintain heading while the laser seeker searches for the laser 'paint' on the target. Once the appropriate laser-coded illumination is acquired, the seeker steers the Copperhead round to impact.

The US Army used the Copperhead extensively during the 1991 Desert Storm campaign, mostly to destroy fixed targets such as radar installations, OPs and bunkers.

The M712 Copperhead was the first semi-active laser homing artillery munition to enter production, designed primarily as a precision guided anti-tank munition (US Army).

The principal issue for the Australian Army in using laser-guided 155mm munitions is the dependency of the weapon upon having a clear, unimpaired line-of-sight to the aimpoint in the latter part of the weapon's trajectory. Experience in Europe indicated that low cloud bases and haze would often delay laser seeker acquisition of the aimpoint until too late in the trajectory to effect a viable flightpath correction, resulting in the round missing.

This problem is exacerbated in jungle fighting, as the high jungle canopies and high ambient moisture levels may well blind the seeker to a ground-based illuminator. In practical terms, laser-guided artillery rounds suffer the same impediments as laser guided bombs: a less forgiving delivery envelope, and higher unit costs due to the need to harden the guidance against thousands of G during launch.

The Russian equivalent to the M712 is the Krasnopol or 'Copperhead-ski', now actively marketed for export in 152mm and 155mm variants. The early 3OF-39 Krasnopol was a two-component round incompatible with autoloaders on the 2S19. This led to the subsequent shorter versions: the Krasnopol-M 152-mm, Krasnopol-155 (KM-1), and Krasnopol-M 155-mm (KM-2). The Krasnopol is claimed to outrange the Copperhead, and carry a larger warhead. Like the Copperhead, the Krasnopol uses switches to program the laser frequency, and has switches to select the time of flight to ballistic cap removal, ballistic or glide mode, and fuse mode. Russian 1D22, 1D20 or 1D15 laser designators are used.

The Krasnopol has been exported to at least 12 countries in Africa, Asia and the Mideast, including India and China. China is apparently manufacturing both the 3OF-39 Krasnopol and Krasnopol-155.

The limitations of laser-guided artillery munitions soon led to the development of satellite / inertial munitions, reflecting the evolution seen in aerial smart bombs. These weapons employ a digital inertial navigation system, which uses a GPS receiver to counter the inertial drift error, achieving excellent accuracy regardless of weather conditions. Effectively these munitions are artillery-fired equivalents of the JDAM bomb family. Like the JDAM, jamming of the GPS typically produces effect only during the terminal flight phase; at best, degrading accuracy of the missile slightly.

The L119 Hamel gun is used primarily to support infantry. It is a light 105 mm weapon, which can be towed or slung beneath a helicopter (BAe).

The US Army's XM982 Excalibur Precision Guided Extended Range Artillery Projectile is intended to enter service in 2006. It exploits payload and base-bleed technology developed for the M864 DPICM. 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 XM85 DPICM submunitions, or 2 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.

It is likely that the Excalibur will soon be followed by a Russian equivalent, and as the Galileo system materialises, EU and Chinese equivalents are anticipated.

The A222 Bereg 130 mm SP Gun is a Russian built coastal defence system, carried on a modified MAZ 543 8x8 chassis. There are no known SPH variants.

Issues for the ADF

There is little doubt that the Australian Army will need to significantly upgrade its field artillery capabilities over the coming decade simply to remain competitive against the region, and to provide capabilities to deal with opponents armed with extended range base-bleed munitions, guided artillery munitions and counter-battery radars. Towed artillery is today highly vulnerable against any opponent using a combination of long-range SPH, guided munitions and counter-battery radar. This is especially true in the domain of 155mm artillery.

The M198 is likely to be replaced in US service with a mix of wheeled SPH and M777, the latter used in benign environments against opponents without artillery capabilities. The question for the Army is whether any towed 155mm artillery should be retained longer term.

The case is less clear cut with L119 Hamel 105mm artillery pieces, used primarily to support infantry. In complex terrain, the L119 can be moved by helicopter to provide artillery fire capability where larger 155mm towed or wheeled SPH systems cannot be deployed. Clearly there would also be a case for an ASLAV-mounted turreted short barrel 105mm gun to support infantry, especially in urban terrain.

The issue of precision or accurate guided artillery munitions is contingent upon whether the investment will be made into appropriate targeting systems, especially tactical UAVs and datalinks to transfer targeting data from aircraft to artillery batteries. Full exploitation of the mobility advantages of new generation lightweight wheeled SPH systems, and extended range smart munitions, will revolve around the presence or absence of adequate targeting capabilities.

US Marines at Falluja prepare an M198 155 mm towed howitzer for firing. The M198 is the largest artillery piece used by the Australian Army (USMC).