CHAPTER 5

Weapons Identification: Light Weapons and their Ammunition

Introduction

Light weapons as a class of arms offer far more firepower than small arms but retain a degree of portability, making them a potent threat in any conflict zone. These weapons are often mounted to vehicles for rapid and flexible deployment. Different types of light weapons are designed for engaging different types of targets, from personnel to aircraft. As such, light weapons range from extraordinarily simple to highly complex weapon systems, and make use of a variety of operating principles and ammunition types.

Light weapons are often described as either 'direct-fire' or 'indirect-fire' weapons.[106] Direct-fire weapons are aimed directly at the target and are generally employed when a target is visible. Direct-fire weapons include small arms, heavy machine guns, light cannon, recoilless weapons, some rocket and missile launchers, and some grenade launchers. Direct-fire weapons are often more accurate than indirect-fire weapons, but generally have shorter ranges and projectiles with smaller payloads (Cross et al., 2016, p. 43).

Indirect-fire weapons are typically employed when the target cannot be observed, is protected by geographic or structural features, or is located a significant distance away. These weapons include mortars, some grenade launchers, some rocket and missile launchers, and larger artillery (Dullum et al., 2017, p. 12).

This chapter begins with a brief overview of key types of light weapons, their physical characteristics, and their markings. A similar analysis of ammunition for light weapons is then provided. The chapter concludes with a brief section on the packaging and documentation often encountered with light weapons and their ammunition.

History and technical development

Heavy machine guns

Heavy machine guns (HMGs) are crew-served automatic firearms, chambered for a cartridge of more than 8 mm but less than 20 mm in calibre (ARES, 2017). One of the earliest and most influential examples of these weapons is the US

106 A small number of light weapons are capable of both direct and indirect fire.

Browning M2 (1936), which was designed for use against armoured vehicles and was chambered for the 12.7 × 99 mm cartridge (see Image 5.1). The M2 was soon rivalled by the Russian DShK (1938), which is chambered for a comparably large cartridge (12.7 × 108 mm) (see Image 5.2). Both guns are belt-fed and typically mounted on vehicles or large, heavy tripods. They were generally used against targets located between 300 and more than 1,000 metres away. Both weapons have been updated since their inception and remain in widespread use alongside more modern models (ARES, 2016a; 2017).

A typical infantry HMG crew consists of a minimum of three operators: one to carry the gun, one the mount, and one or more to carry and load ammunition. HMGs are often used to deliver sustained fire in situations where small arms would be prone to overheating. Some early HMGs featured water cooling systems, but most now have very heavy and/or interchangeable barrels to deal with the

Image 5.1 A Russian DShKM HMG

Source: Small Arms Survey

Image 5.2 An American Browning M2 HB HMG

Source: US Department of Defense

high temperatures generated by automatic fire. So-called 'quick-change' barrels are increasingly common, allowing operators to replace overheated or worn barrels rapidly (ARES, 2017).

Light cannon

The term 'light cannon' encompasses several types of rifled firearms chambered for medium-calibre cartridges (20 mm – <57 mm) that meet the criteria of light weapons (ARES, 2017). Most of the weapons in this category are considered to be 'anti-materiel rifles' (AMRs) (see Image 5.3; Chapter 3), but the category also includes a smaller number of semi-automatic and automatic weapons designed to be employed from a mount or vehicle. These latter weapon systems are commonly referred to as 'autocannon' and are often, although not exclusively, employed in an anti-aircraft role (see Image 5.4). Most of these weapons are too heavy to be considered 'light weapons'; however, a handful meet the light weapons' weight and crew criteria. The cut-off between medium- and large-calibre ammunition is

Image 5.3 A South African Denel NTW20 20 × 82 mm[2] light cannon, considered by many to be an anti-materiel rifle

Source: US Department of Defense

Image 5.4 A Solothurn S18-1100 20 × 138B mm autocannon, in an anti-aircraft mount

Source: Wikimedia Commons/Hmaag

generally understood to be 57 mm; this therefore provides the theoretical upper limit for this class. In practice, the clear majority of weapons in this category are chambered for 20 mm cartridges (ARES, 2016a; 2017). Exceptions include craft-produced AMRs chambered for the powerful 23 × 152B mm cartridge, which have been employed by a range of non-state actors in Iraq, Syria, Ukraine, Yemen, and elsewhere (Hays and Jenzen-Jones, 2018). Several weapon systems commonly and erroneously considered to be light cannon do not meet the definition of light weapons because of their total system weight, and so are excluded from this category. The excluded weapons are generally considered 'medium cannon'. An example is the Soviet ZU-23-2 (ARES, 2017).

Shoulder-fired grenade launchers

Hand-held grenade launchers are weapons that fire specially-designed subsonic cartridges or semi-caseless ammunition of 20 mm to 40+ mm calibre, typically to a maximum range of 400–1,000 m (see, for example, Images 5.5 and 5.6). Grenade launchers generally fire projectiles containing high-explosive (HE) warheads, but most launchers also fire other projectiles, such as inert training, less-lethal, and illumination ammunition (ARES, 2017).[107] In military use, grenade launchers are generally issued at the infantry section or squad level. Recent developments

107 Illumination rounds are designed to provide supplemental visible spectrum and/or infrared (IR) light to aid in operations. This is usually achieved by ignition of a pyrotechnic candle or flare (US Army, 1991). The increased use of night vision devices in combat has resulted in the development of IR spectrum candles that do not emit any appreciable visible light. See, for example, Bacon (2011).

Image 5.5 An American M79 break-action 40 × 46SR mm grenade launcher

Source: N.R. Jenzen-Jones/ARES

Image 5.6 A Bulgarian Arsenal MSGL revolver-type 40 × 46SR mm grenade launcher

Source: Wikimedia Commons/MarinaJord

include computer-controlled sighting and fuzing systems that allow for the detonation of ammunition over targets hiding behind low walls, earth berms, hills, and other uneven terrain ('airburst') (Jenzen-Jones, 2015a). Several modern grenade launchers are designed for standalone use or as under-barrel launchers (ARES, 2017).[108]

Broadly speaking, launchers in 40 mm calibres are multipurpose (that is, able to fire different ammunition types), and almost invariably have rifled barrels (ARES, 2017). While outwardly similar in appearance, so-called 'riot guns', commonly chambered for 37/38 mm projectiles, are specifically designed for non-lethal and less-lethal applications including the launching of flares, and predominantly have smooth-bore barrels (ARES, 2017).

108 Examples include the German Heckler & Koch GLM (M320 in US military service) and Belgian FN Herstal FN40GL.

Auxiliary grenade launchers

Auxiliary grenade launchers, most commonly under-barrel grenade launchers, were first deployed experimentally by the United States in the Vietnam War. The first widely issued model was the US-designed Colt M203 (1969), a breech-loading weapon chambered for the 40 × 46SR mm cartridge. Russia followed a different development path and introduced the muzzle-loading GP-25 in 1978, firing a semi-caseless 40 mm projectile (see Image 5.7). Both models were designed to be mounted on an existing weapon (the 'host weapon'), typically an infantry rifle (ARES, 2017). Auxiliary grenade launchers usually consist of a barrel, a trigger mechanism, some sort of mounting system, and a special sight (typically a 'ladder sight') that is fitted to the host weapon (see Images 5.8 and 5.9). Most designs are manually operated, with some form of sliding or pivoting barrel to provide access for loading. Grips and butt-stocks are typically not included, but recent designs allow for the addition of a gripstock, effectively converting the weapon into a hand-held launcher (ARES, 2017). Some modern launchers also feature electronic aiming aids or sensor fuzing (see Box 5.1).

Image 5.7 A Serbian Zastava Arms BGP40 semi-caseless 40 mm under-barrel grenade launcher, a close copy of the Soviet GP-25 design

Source: N.R. Jenzen-Jones/ARES

Image 5.8 A US M203A2 manually-operated 40 × 46SR mm under-barrel grenade launcher mounted to an M4A1 self-loading rifle

Source: US Air Force

Image 5.9 A Belgian FN Herstal FN40GL manually-operated 40 × 46SR mm under-barrel grenade launcher mounted to a FN Herstal SCAR-L self-loading rifle

Source: N.R. Jenzen-Jones/ARES

Crew-served grenade launchers

Crew-served grenade launchers are self-loading guns that fire medium-calibre explosive projectiles at relatively low velocities and at a relatively slow rate of automatic fire (ARES, 2017; Jenzen-Jones, 2015a, pp. 1–2). Sometimes called automatic grenade launchers (AGL) or grenade machine guns (GMG), these weapons are typically belt-fed and are operated by a small crew (see, for example, Image 5.10). The first widely issued crew-served grenade launcher was the US-designed Hughes MK 19 (1968), which was quickly followed by the Russian AGS-17 in 1971. Crew-served grenade launchers are generally intended for defending static positions and supporting infantry, but are often adapted for use on vehicles, including aircraft. Recent development trends include longer-range ammunition, and the increased use of sophisticated fire control systems (FCS) to enhance accuracy and achieve specific effects such as airburst (Jenzen-Jones, 2015a, p. 2; ARES, 2017; see Box 5.1 and Image 5.11).

Image 5.10 A Russian AGS-30 AGL with a simple optical sight

Source: Wikimedia Commons/Vitaly V. Kuzmin

Image 5.11 A US General Dynamics Ordnance and Tactical Systems MK 47 Mod 0 STRIKER AGL with a Raytheon Lightweight Video Sight fire control system

Source: Australian Department of Defense

Box 5.1 FCSs and airburst munitions for AGLs

There has been a limited trend towards lightweight AGLs fitted with advanced FCSs (see Image 5.11), often paired with an airburst munitions (ABMs) capability (see Image 5.12). Use of these control systems increases the probability of hitting the target with the first round, allowing operators to surprise adversaries, rapidly engage multiple targets, and reduce ammunition consumption. The increased accuracy provided by these systems also has the potential to reduce collateral damage. Using FCSs with ABMs allows operators to reliably engage targets hidden behind hills or other features of the terrain for cover (targets 'in defilade') (Jenzen-Jones, 2015a, p. 2).

ABMs use information provided by the FCS to program the projectile to detonate at a precise point in space above or next to the target. The rounds are typically programmed either through contact with the barrel of the weapon, or through radio frequency (RF) or infrared (IR) signals (Jenzen-Jones, 2015a, pp. 2–3). Some FCS are integral to the weapon system, while others can be added to existing guns.

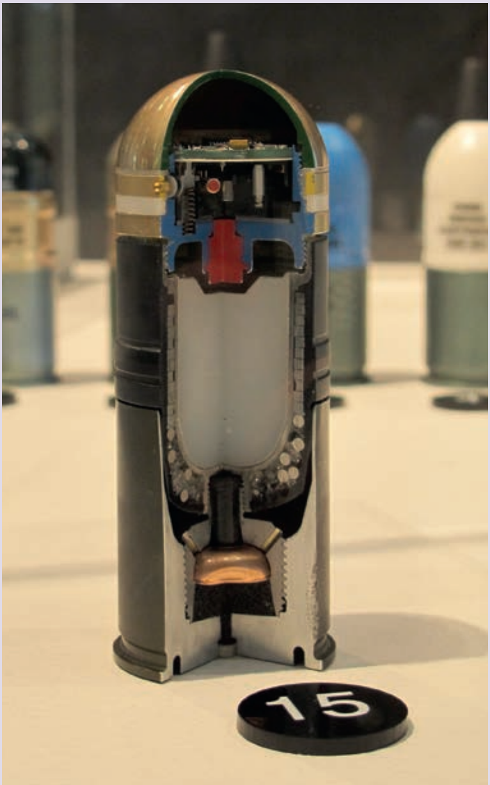


Image 5.12 Nammo MK 285 programmable pre-fragmented high-explosive (PPHE) 40 × 53SR mm ABM

Source: N.R. Jenzen-Jones/ARES

Light and medium mortars

Light and medium mortars are portable, indirect-fire infantry support weapons. Modern mortar designs date back to the early 20th century and consist of a simple smooth-bore barrel (sometimes called a 'tube') with a fixed firing pin at the base that fires the round when it is dropped into the tube. The tube is generally attached to a baseplate and supported by a bipod (see Image 5.13). This lightweight, tactically flexible design has proved useful, and weapons of the same basic type have been in use ever since (Bull, 2004, pp. 181–82; ARES, 2017).[109]

109 There are a few rare exceptions, such as breech-loading mortars which can be employed in the direct-fire role. Alternative propulsion systems have also been developed, notably the German Rheinmetall 'FLY-K' system and its copies, which effectively suppress both sound and infrared signatures (Jones and Ness, 2013).

Image 5.13 A British Stokes 3-inch 'light trench mortar'

Source: Imperial War Museums

Image 5.14 Serbian M69 82 mm mortar (foreground) and M57 60 mm mortar (background)

Source: Wikimedia Commons

The main advances in mortar technology since 1918 have been in projectile and propellant design. Recently-produced mortar rounds have an aerodynamically shaped warhead with an additional finned propulsion tail section, which together increase range, accuracy, and precision.

Like machine guns, mortars are commonly classified by their intended role, which correlates with calibre and portability. Generally, the larger the projectile, the longer its range. 'Light mortars' (50–60 mm) have typical ranges of one to three kilometres; a 60 mm mortar is the upper practical limit in size for a crew of three, largely due to the weight of the ammunition. NATO and other 'Western' military forces generally use 81 mm calibre weapons for 'medium mortars', while former Warsaw Pact countries primarily employ 82 mm equivalents (ARES, 2017; Jones and Ness, 2013; see Image 5.14). Generally speaking, these systems have effective ranges of three to six kilometres and require a crew of four or five to carry and operate. 'Heavy mortars' are similar in function and capabilities to larger towed mortars and other artillery pieces; several common heavy mortars have ranges in excess of seven kilometres, with very large systems reaching as far as ten kilometres (Jones and Ness, 2013).

When firing a typical mortar, the range of the projectile and the point of impact can be adjusted both by angling the tube and, generally, by using different sizes or quantities of auxiliary propellant charges, which increase the range of the mortar round (Hogg, 2001). Firing in a very high, arcing trajectory, mortars require specific sighting and laying systems. Conventional mortars do not have recoil mechanisms, with the main recoil force being transmitted directly to the ground via the baseplate. Most mortars are only capable of firing at high-angle trajectories (above 45 degrees), precluding their use as direct-fire weapons. There are exceptions, including rifled mortars, direct-fire mortars, and self-loading mortars (Dullum et al., 2017, pp. 27, 30), but these systems are limited in number.

It is now possible to employ Global Positioning System (GPS) and laser-guided projectiles from existing mortar systems. These guided mortars are now produced and employed by several states, and offer significant advantages over traditional systems, most notably greatly enhanced precision. Often, no modifications are necessary to the mortar itself, since the guidance system is located within the projectile or is part of a bolt-on upgrade kit for existing rounds (see Image 5.44) (Jenzen-Jones, 2015b, pp. 1–2).

Recoilless weapons

Recoilless weapons are generally sorted into two subcategories: crew-served recoilless weapons and shoulder-fired recoilless weapons (alternatively called handheld recoilless weapons; see Image 5.15).[110] Common crew-served recoilless weapons include the American 106 mm M40, and the Soviet-designed 82 mm B-10 (1954) and SPG-9 (1962) (Tucker, 2015; see Image 5.16). The second subcategory of recoilless weapons includes the widely proliferated RPG-7-pattern launchers (1961) (see Box 5.2) and the Swedish 84 mm Carl-Gustaf (1946). These weapons are usually carried and fired from the shoulder of a single operator. Even though these weapons were developed decades ago, many are still in use, and despite numerous upgrade programmes, key operating principles have changed very

110 The first recoilless weapon adopted for military service used an operating principle which employed a counter-mass of lead balls to equalize the otherwise high recoil generated on firing a large and heavy projectile. Later designers realized that it was possible to utilize less hazardous counter-mass materials such as powders or liquids, or even to rely upon the propellant gases alone (Jenzen-Jones, 2015c, pp. 1, 3–4). Some recoilless weapons feature an auxiliary co-axial gun (often termed a 'spotting rifle') to facilitate aiming (ARES, 2017).

little since they were first introduced. Manufacturers, however, have introduced several new types of ammunition, including rounds with tandem charges to defeat reactive and bar armour, multipurpose ('bunker-buster') rounds, along with anti-personnel, illumination, smoke, and training/practice (TP) rounds (ARES, 2017; Jenzen-Jones, 2015c).[111]

Image 5.15 A Swedish Saab AT4 shoulder-fired recoilless weapon

Source: Saab

Image 5.16 A Russian SPG-9 crew-served recoilless gun

Source: Small Arms Survey

111 Smoke is primarily used as an obscurant to mask the location or movement of military units, but also for signalling and diversion purposes. Different smoke compounds and release mechanisms are designed to provide smokescreens of specific size, duration, and effect (US Army, 1991, p. 12). Some smoke compositions (for example, white phosphorous) can have an incendiary effect.

Rocket launchers

The first anti-tank rocket launcher to be widely fielded was the US M1 Bazooka (1942). The Bazooka and its successors are sometimes referred to as 'man-portable anti-tank systems' (MANPATS or MPATS). However, they are also frequently used to engage other types of vehicles, infantry, structures, and occasionally even aircraft.[112] The rocket launch tube may be reloadable, or disposable, in which case only one round is fired and the tube is then discarded (see Image 5.17). Rocket launchers should not be confused with recoilless weapons (see Box 5.2) despite their overlapping role and some similar operational characteristics (ARES, 2017).

As with recoilless weapons, rocket launchers are divided into two broad categories: crew-served and shoulder-fired (or 'hand-held') (ARES, 2017). Crew-served rocket launchers are almost invariably reloadable. Some shoulder-fired launchers are reloadable while others are disposable.

Image 5.17 American Talley Defense Systems M72 light anti-tank weapon (LAW) series shoulder-fired disposable single-shot 66 mm rocket launchers

Note: (a) M72A3 in extended (ready-to-fire) position; (b) M72 in stowed position.
Source: Bear Arms Firearms Reference Collection via ARES

112 Some variants of rocket launchers designed for use against structures are known as 'anti-structure munitions' or 'ASM' (ARES, 2017).

Box 5.2 Myths and misconceptions: 'rocket launchers' versus 'recoilless weapons'

The difference between rocket launchers and recoilless weapons is a consistent source of confusion. The confusion stems in part from the fact that rocket launchers such as the M72 LAW are sometimes described as recoilless, in the sense that the operator perceives very little recoil. The key difference, however, is that rocket launchers do not propel rockets, which incorporate their own source of propulsion and would still fire successfully if ignited outside their launch tube (Newhouse, 2011). In contrast, recoilless weapons have a functional barrel that contributes directly to the acceleration of the fired projectile, which is propelled out of the barrel by the expanding gases generated by burning propellant.

Several common light weapons employ a combination of recoilless and rocket propulsion principles. Typically, these systems use an expelling charge to launch a projectile a short distance from the weapon, at which point a rocket motor ignites and propels the projectile towards the target. A well-known example of such a system is the RPG-7 (see Image 5.18). A typical RPG-7 round, such as the PG-7V, uses an expelling charge—often erroneously referred to as a 'booster section'—to launch the projectile several metres from the barrel before the rocket motor engages and provides most of the required acceleration (US Army TRADOC, 1976). This 'two-stage' launch protects the operator from the rocket's back blast. The most common ammunition fired from RPG-7-pattern launchers employ a combination of recoilless and rocket propulsion principles, while some projectile types, including the widely proliferated OG-7V anti-personnel round, operate purely on the recoilless principle. Other hybrid systems include the German Panzerfaust 3 and the Swedish AT4 (Jenzen-Jones, 2015c, p. 2; see Image 5.15).

Image 5.18 A Russian RPG-7V shoulder-fired recoilless weapon

Source: Small Arms Survey

Anti-tank guided missile systems

As the name implies, man-portable anti-tank guided missile (ATGM) systems are distinguished from unguided anti-tank systems such as the RPG-7 or Carl-Gustaf by the incorporation of targeting and guidance systems. ATGMs, which are also referred to as anti-tank guided weapons (ATGWs), were originally designed to disable armoured vehicles, but are frequently employed against other targets, such as personnel, light vehicles, and hardened structures (Jenzen-Jones, 2017a, p. 1).[113]

First-generation ATGM systems, including the widely proliferated Russian 9K11 Malyutka, operate on the 'manual command to line-of-sight' (MCLOS) principle, requiring an operator to manually guide the missile onto the target. The operator uses a joystick-like control that sends signals to the missile through thin wires trailing behind it (Fulmer, Jenzen-Jones, and Lyamin, 2016; Jenzen-Jones, 2017a, p. 1). This guidance system requires a high degree of skill to operate (Jenzen-Jones, 2017a). Many first-generation missiles were fired from rails or boxy metal housings.

Second-generation missiles, such as the US-designed BGM-71 TOW (adopted in 1970), typically feature reusable launchers and missiles in self-contained launch tubes. These missiles are much easier to use than their predecessors due to the introduction of semi-automatic command to line-of-sight (SACLOS) guidance systems (see Image 5.19). The operator simply has to keep the target in the crosshairs of the weapon's sight, and the missile does the rest (Fulmer, Jenzen-Jones, and Lyamin, 2016). Some second-generation missiles are wire-guided while others have radio, laser, and optical guidance systems. These missiles often have effective ranges of between 2,500 and 5,500 m with warhead armour penetration of up to 900 mm—almost twice the range and effectiveness of first-generation models (Ness and Williams, 2007, pp. 445–509; Jenzen-Jones, 2017a, pp. 1–2).[114]

Because the operator of most first- and second-generation ATGMs stays in one location while guiding the missile to the target, they are vulnerable to counter-attack. Some later systems, such as the US-designed FGM-148 Javelin (1996),[115] are 'fire and forget' weapons, using an advanced suite of electro-optical sensors to store the designated target location and automatically steer the missile to it. Fire and forget systems are often lighter and capable of being broken down into smaller component parts for transportability (Jenzen-Jones, 2017a, p. 2).

113 The term 'anti-tank guided weapons' also includes other guided anti-tank systems, such as guided artillery projectiles, guided mortar projectiles, and others (ARES, 2017).

114 Armour penetration is often measured in 'rolled homogeneous armour equivalency' (RHAe), which is not directly equivalent to the thickness of a given vehicle's armour.

115 Currently manufactured by Raytheon/Lockheed Martin. The Javelin was originally developed by a joint venture of Texas Instruments and Martin Marietta (Chait, Long, and Lyons, 2006).

Image 5.19 A Russian 9K135 Kornet-E SACLOS ATGM with 9M133 series missile

Source: Vitaly V. Kuzmin

The latest generation of ATGMs also tend to employ a top-attack profile in which the missile executes a 'pop-up' manoeuvre just prior to impact, targeting the top of the vehicle, which is often its weakest point (Jones and Ness, 2013).[116] Such systems are capable of hitting targets from long distances; some modern ATGMs have ranges of eight kilometres or more. Recent warhead designs include multipurpose and anti-personnel warheads, and tandem charges to defeat modern vehicle armour (ARES, 2017; Jenzen-Jones, 2017a, pp. 2–3).

Man-portable air defence systems

Man-portable air defence systems (MANPADS) are a class of relatively lightweight, short-range surface-to-air missile (SAM) systems designed to engage low-flying aircraft (ARES, 2017; Jenzen-Jones, 2017b, p. 1; see Image 5.20).[117] They are derived from earlier and larger SAM systems conceived during the Second World War. When operated by a crew rather than an individual, these systems are sometimes referred to as crew-portable air defence systems (CREWPADS) (ARES, 2017).

The first MANPADS to be fielded was the US FIM-43 'Redeye', introduced during the Vietnam War (1967). The Redeye was the predecessor of the FIM-92 Stinger, which is famous for its use in Afghanistan in the 1980s (Phillips, 2011). A year later, in 1968, Russia issued the 9K32 Strela-2, known to NATO as the SA-7a Grail. This system and the updated 9K32M Strela-2M (SA-7b) proliferated across the globe in the decades that followed (see Image 5.20) (ARES, 2017).

116 A top-attack profile is sometimes called overfly top-attack (OTA) capability. Top-attack profiles are sometimes used against targets other than vehicles.

117 MANPADS and other short-range SAMs generally have maximum ranges of less than 10,000 m. Medium- and long-range SAMs have maximum ranges more than ten times those of short-range models (Jenzen-Jones, 2017b, p. 3).

Image 5.20 A 9K32M Strela-2M MANPADS and its 9M32M SAM

Source: US Department of Defense

Most MANPADS consist of four main components: a missile in a disposable launch tube, a gripstock, and a battery (see 'Barrels and launch tubes' section). The vast majority of these systems are 'fire and forget' weapons, meaning that, after the missile is launched, it guides itself to the target with no input from the operator. In most cases, the missile's seeker detects the infrared energy emitted by the targeted aircraft. Early systems were only effective when fired from behind the aircraft, when the target's hot engines and airframe are easiest to detect and track. So-called second- and third-generation systems such as the Russian 9K38 Igla (SA-18) are capable of 'all-aspect' tracking, meaning that the missile can engage the target from the front, sides, or rear. Some of these systems are able to differentiate between the target and simple countermeasures, such as flares. Later-generation MANPADS are also faster and more manoeuvrable, and have longer ranges and more effective warheads than the older systems (ARES, 2017).

A small number of MANPADS employ other types of guidance systems. These weapons are guided by either radio signals, such as the British Javelin,[118] or laser beams, such as the Swedish Bofors RBS 70 (Jenzen-Jones, 2017b).[119] MANPADS with infrared seekers are by far the most common, however (PM/WRA, n.d.). Some of the newer models of these systems feature 'all-target' warheads, which have a limited capability to engage ground vehicles (Saab, 2016; see Image 5.21).

118 The British Javelin MANPADS is not to be confused with the ATGM of the same name, described in the previous section.

119 Bofors is now part of Saab.

Image 5.21 A Swedish Saab RBS 70 NG CREWPADS firing BOLIDE 'all-target' SAM

Source: Saab

Physical features

The physical features of light weapons are much more varied than small arms. Some types of light weapons, such as HMGs and cannon, share many features with small arms, whereas other weapons, including recoilless weapons and mortars, follow wholly different design philosophies and architecture. Broadly speaking, many of the same physical characteristics and markings present on small arms are also present on light weapons. There are some additional considerations, however, which are outlined below.

Bodies and receivers

HMGs and cannon feature what are essentially scaled-up machine gun receivers (ARES, 2017). HMG receivers are unmistakeably larger and more robust than their smaller counterparts (see Image 5.22). In many cases, substantial rivets, bolts, and welds are visible (see Image 5.23). The patterns of rivets and welds may prove a useful feature for differentiating between visually similar light weapons, such as the NSV and Kord HMGs.[120] Most mortars, rocket and missile launchers, and some recoilless weapons do not have a receiver in the conventional sense.

120 See, for example, Ferguson (2014c).

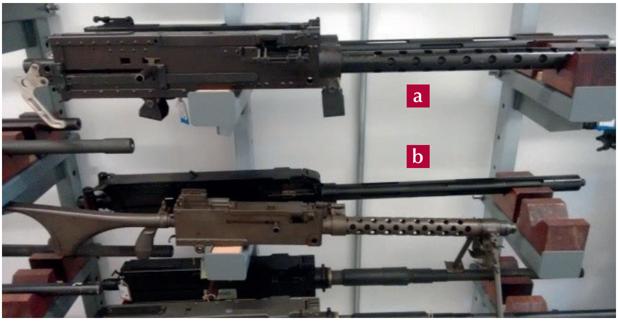
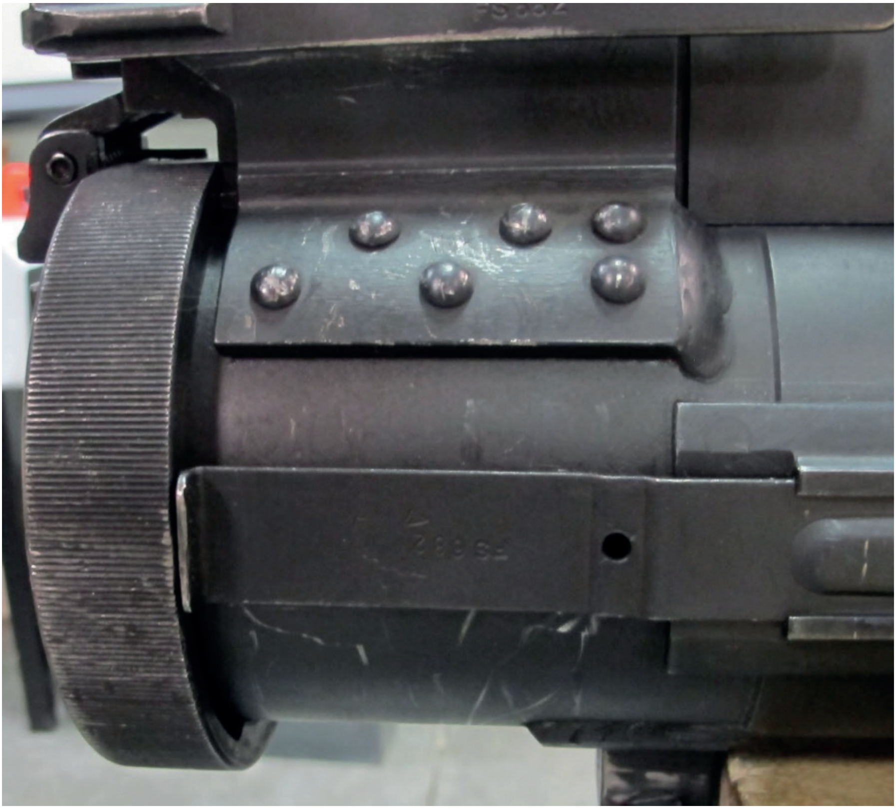


Image 5.22 A Browning M2 HMG and its close relative and small arms equivalent, the M1919A6

Note: The M1919A6 (b) is smaller but similar to the Browning M2 (a) in appearance.
Source: Jonathan Ferguson/ARES

Image 5.23 The rear of the receiver of a Romanian copy of a KPV HMG



Note: The receiver has a substantial weld and large rivets.
Source: N.R. Jenzen-Jones/ARES

Baseplates

As noted above, most mortar systems consist of a stabilizing baseplate, a barrel, and a bipod. The baseplate transmits recoil forces to the ground or other supporting surface, reducing their effects on the aim of the weapon (see Image 5.24). It is possible that a mortar baseplate might be found in isolation, if the intent is that a position will be reused, or if a mortar team has been disrupted or killed in action. It is worth noting that baseplates may themselves be affixed to concrete floors or vehicle flatbeds.

Image 5.24 The circular baseplate of a British L16 81 mm mortar

Note: The large bipod is used to support and adjust the angle of the barrel, and to provide a mount for the optical sight bracket.
Source: Wikimedia Commons/Hisamikabunomura

Barrels and launch tubes

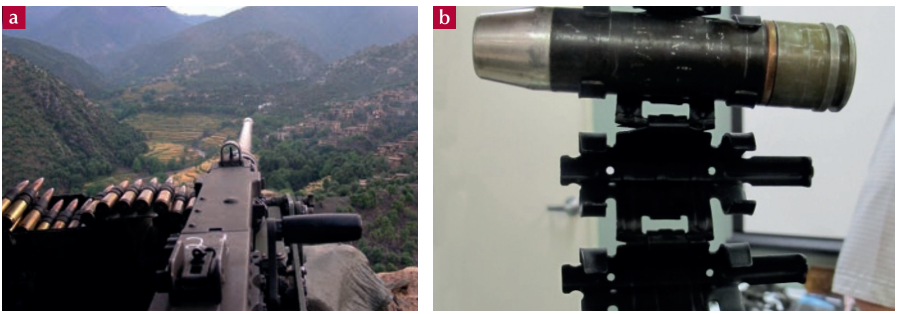
Although similar in some respects, barrels and launch tubes are distinct components. A barrel is designed to bear significant internal pressures and is sealed at one end to prevent the escape of gas. Launch tubes are not subject to substantial pressures, and act primarily as a guide. Barrels may be rifled or smooth-bore, and light weapons with barrels may be breech- or muzzle-loading (though muzzle-loading is now rare, aside from mortars).

HMGs and cannon generally employ medium-calibre (12.7 mm to >57 mm) rifled barrels that are noticeably larger and heavier than small arms. Barrels for HMGs are likely to be readily detachable, but cannon barrels are not (due to their significant mass and slower rate of fire). Automatic grenade launcher barrels are most often larger in calibre but shorter in length and may be rifled or smooth-bore. Most are not quickly detachable. Barrels for recoilless weapons and mortars are typically more robust than rocket or missile launch tubes, as they are pressure-bearing parts more akin to the barrel of a firearm or artillery piece.

Feed devices

Feed devices for HMGs and cannon are often similar to the feed devices of small arms. Most commonly, these devices consist of a belt-feed system of cartridges in disintegrating or non-disintegrating links that are stored and fed from metal ammunition boxes (see Image 5.25). In some cases, light weapons firing conventional cartridge-based ammunition—including AMRs, light cannon, and grenade

Image 5.25 Examples of belted ammunition



Note: (a) Belted ammunition loaded into a Browning M2 HMG from a metal storage or transit box attached to the weapon's soft-mount. (b) A 30 × 29B cartridge for AGS-17 type grenade launchers loaded into a belt, with two empty links.
Sources: US Department of Defense; N.R. Jenzen-Jones/ARES

launchers—feed from oversized box magazines. Recoilless weapons and rocket launchers are either disposable or reloadable, as described above. Generally speaking, reloadable recoilless weapons and rocket launchers do not feed from external feed devices, although there are exceptions.

Accessories

The range of optional accessories for light weapons is significantly smaller than that for small arms. Some are encountered with optical sights (see Image 5.26), and HMGs and cannon are often found with spare barrels, parts kits, and specialized load-bearing and/or storage equipment for the weapon and its ammunition. These items sometimes help with the identification of an absent weapon.

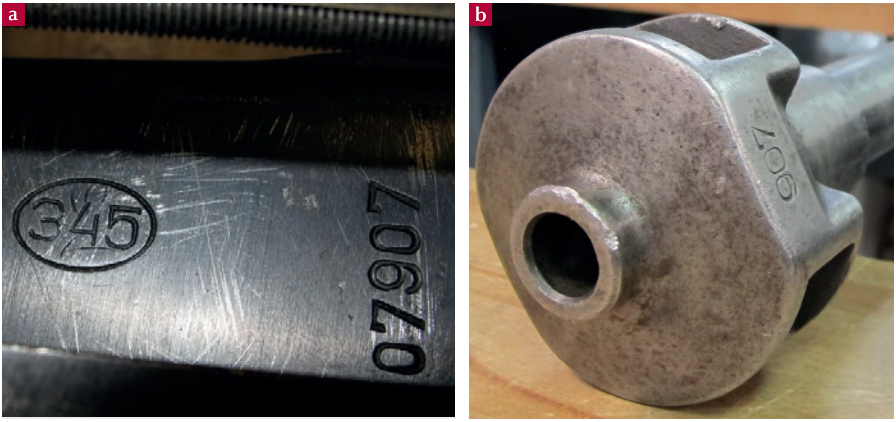
Image 5.26 An M2 type HMG fitted with various optical sight systems

Source: NIOA

Markings

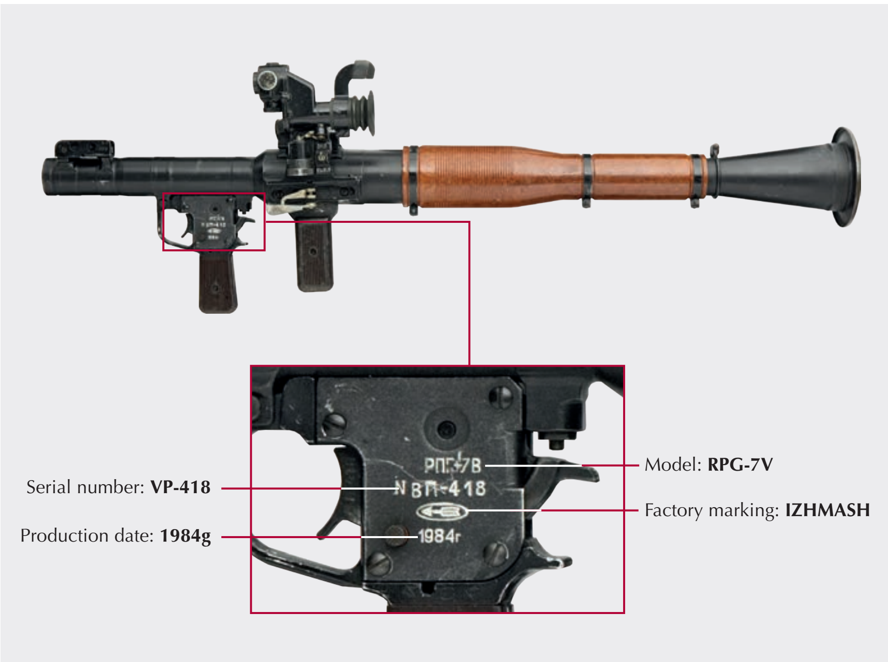
The patterns and formats of light weapons markings are similar to those on small arms (see Chapter 3), but their format, size, and location are more varied. Like small arms, the markings on most light weapons are stamped or engraved on the receiver and other key components. The information conveyed by the markings often includes the make, model, calibre, production year, and serial number (see Images 5.27–5.30).

Image 5.27 Markings on a Polish DShKM



Note: (a) Factory marking, serial number, and inspection mark on a Polish DShKM. (b) Partial serial number (907) reproduced on the muzzle device of the same weapon.
Source: N.R. Jenzen-Jones/ARES

Image 5.28 Markings on a Russian RPG-7V launcher



Source: Small Arms Survey

Image 5.29 Markings on the rear of an M40A1-pattern recoilless gun

Note: The markings reveal several key details such as the type of weapon (CAÑON S/R; for cañon sin retroceso, or 're-coilless gun'), calibre (106MM), model (M40A1), and year of production (AÑO 1973).
Source: Peter Bouckaert/HRW

Image 5.30 A safety/operation warning marked on a Serbian Zastava M93 self-loading crew-served grenade launcher

Note: The warning reads 'ПРВИ ЧЛАНАК НА РЕДЕНИКУ МОРА БИТИ ПРАЗАН', which means 'first link in belt must be empty'.
Source: N.R. Jenzen-Jones/ARES

Some markings are stencilled or hand-painted onto light weapons. This practice is particularly common with regards to MANPADS and ATGW missile tubes, as well as various rocket launchers and recoilless weapons. These items often have additional markings that are stamped or engraved.

Markings on some light weapons are stamped or printed onto a metal plate (see Image 5.31).[121] Such plates, which are riveted or screwed onto a key component, are often easily and untraceably removed. Image 5.32 shows a markings plate on a sighting unit for a US-designed TOW ATGM system.

Image 5.31 Marking plate on a 9P58 gripstock for the 9K32M Strela-2M MANPADS

Source: ARES (n.d.)

Image 5.32 Marking plate on an American Hughes Aircraft Co. TOW ATGM launch unit

Source: N.R. Jenzen-Jones/ARES

121 Sometimes called a 'marking plate' or 'data plate'.

Mortar barrels, baseplates, and mounts are sometimes marked, but may also be unmarked, or only have a serial number (see Images 5.33 and 5.34). Additionally, the serial number on the baseplate may not match the number on the barrel. Some marking indicating the model of weapon to which a baseplate or mount belongs is likely, but not present in all cases.

Image 5.33 Markings on the muzzle end of a British L16A2 81 mm mortar barrel

Note: These markings show the calibre (81MM), model/military designation (L16A2), and registration number ('REG №…' partially obscured). The complete markings also include the year of manufacture and other details.
Source: N.R. Jenzen-Jones/ARES

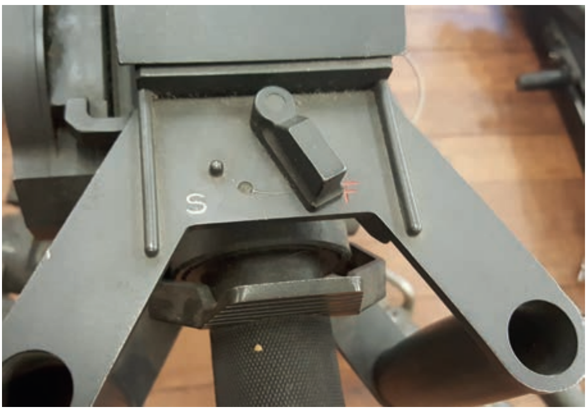


Image 5.34 Fire selector markings (S, F) on a Vektor Y3 crew-served 40 × 53SR mm automatic grenade launcher

Note: The Vektor Y3 is now marketed as the Denel GLI-40.
Source: N.R. Jenzen-Jones/ARES

Ammunition for light weapons

Cartridges for HMGs, anti-tank rifles, and AMRs (20 mm or less)

Ammunition for HMGs is, by definition, small-calibre ammunition (see Chapter 4). Among the most common cartridges in this category are the American 12.7 × 99 mm, also known as the .50 BMG (Browning Machine Gun), and the Soviet 12.7 × 108 mm, both of which were fielded prior to the Second World War and remain in widespread service today (Williams, 2000; see Table 5.1 and Image 5.35). While intended primarily for use against armoured vehicles such as tanks, as well as aircraft and other targets, it quickly became apparent that the rapidly increasing thickness of tank armour rendered these rounds ineffective in the anti-armour role. Ammunition for anti-tank rifles (ATRs) and AMRs is often interchangeable with that used by HMGs.[122] As a result, these weapon systems were subsequently fielded for use against personnel, light structures, unarmoured vehicles, helicopters, and other materiel. HMGs are still widely used against these targets today (ARES, 2017).

Table 5.1 Selected HMG cartridges in military service

Cartridge designation	Country of origin	Projectile type	Projectile weight (g)
12.7 × 99 mm	United States	API	43
12.7 × 108 mm	Soviet Union	API	52
14.5 × 114 mm	Soviet Union	API	64

Note: All figures are approximations and vary according to cartridge type and loading, and other factors.
Sources: Koll (2009); Williams (n.d.; 2000)

122 The final generation of ATRs adopted special ammunition. The German and Polish armies chose a small-calibre projectile fired at very high velocity, enabled by a large cartridge case (the 7.9 × 94 mm Panzerbuchse and 7.92 × 107 mm Maroszek cartridges, respectively) (Williams, 2000). Other nations developed bigger and much more powerful rounds, particularly the Soviet 14.5 × 114 mm cartridge as used in the PTRD and PTRS rifles, which towards the end of the Second World War was adopted for use in a large HMG, the KPV, variants and derivatives of which remain in widespread service worldwide (ARES, 2017).

Image 5.35 Some sample cartridges used with HMGs, ATRs, and/or AMRs

Note: (a) 7.62 × 51 mm (for scale); (b) 13 × 92SR mm TuF; (c) 7.9 × 94 mm Panzerbuchse; (d) 12.7 × 99 mm (.50 BMG); (e) 12.7 × 108 mm; and (f) 14.5 × 114 mm.
Source: Anthony G. Williams/ARES

Physical features

Most ammunition for HMGs closely resembles the small-calibre cartridges used in standard infantry rifles and light and general-purpose machine guns, albeit scaled-up considerably (see Chapter 4). These cartridges are commonly produced from drawn brass or steel cartridge cases and typically employ full metal jacket ('ball') bullets, with cores that are usually made of steel. Other commonly encountered functional types includes armour-piercing incendiary (API) rounds and semi-armour-piercing high-explosive incendiary (SAPHEI) rounds. API bullets normally have hardened steel cores with a small quantity of incendiary material in the jacket tip. Multipurpose SAPHEI bullets have a more complex internal structure, including tungsten alloy penetrators, HE composition, and a jacket nose filled with incendiary material (ARES, 2017; Williams, 2000).

Markings

Ammunition for HMGs and AMRs is typically marked in a manner consistent with other small-calibre ammunition, including the headstamp and tip colour code (see Chapter 4).

Light cannon cartridges (20 mm – <57 mm)

Light cannon fire medium-calibre cartridges. As noted above, these are, in practice, largely restricted to cartridges of 20 mm in calibre (see Table 5.2 and Image 5.36).

Table 5.2 Dominant light cannon cartridges in global military service

Cartridge designation	Country of origin	Sample 'AMR' light cannon	Sample autocannon	Projectile type	Projectile weight (g)
20 × 82 mm / 20 × 83.5 mm	Germany / South Africa	Denel NTW20	Denel GA-1	HE	115
20 × 102 mm	United States	Anzio Ironworks models	Nexter 20M621	HE	101
20 × 110 mm	France	H Alaan RT-20	Hispano-Suiza HS.404	HE	130
20 × 128 mm	Switzerland	None known	Oerlikon KAA	HE	120
20 × 138B mm	Switzerland	Solothurn S18-1000	Breda Model 35	HE	119
20 × 139 mm	Spain	None known	Rheinmetall Rh 202	HE	120
23 × 152B mm	Soviet Union	Craft-produced AMRs	ZU-23-2	HEI	184

Notes: All figures are approximations and vary according to cartridge type and loading, and other factors. Several of the example autocannon given would not be classified as light weapons, and are provided only for context.
Sources: Hays and Jenzen-Jones (2018); Koll (2009); Williams (2000; 2007)

Image 5.36 Examples of cartridges used with light cannon

Note: (a) 12.7 × 99 mm (for scale); (b) 20 × 83.5 mm (near copy of 20 × 82 mm); (c) 20 × 110 mm; (d) 20 × 102 mm; (e) 20 × 128 mm; (f) 20 × 139 mm; (g) 20 × 138B mm; and (h) 23 × 152B mm.
Source: Anthony G. Williams/ARES

The first issued light cannon, the 20 mm Becker, was introduced by Germany during the First World War. During the Second World War, combatants used a wide range of cannon in different calibres from many manufacturers. Principally, these weapons were employed by or against aircraft, but they were also used in ground fighting roles, particularly when mounted on vehicles (Williams, 2000). In recent decades, there has been a gradual increase in the size and power of light cannon mounted on armoured vehicles, but 20 mm guns remain popular for many purposes (ARES, 2017). As noted above, most cannon are not categorized as light weapons because of their weight.

Traditional light cannon cartridge types include:

- High explosive (HE) and high explosive incendiary (HEI): these cartridges feature a hollow steel projectile filled with high-explosive and, in some cases, incendiary composition (see Image 5.37a).

- Semi-armour-piercing high-explosive (SAPHE) or SAPHEI: these cartridges feature a stronger projectile with a hard point, generally employing a base fuse (see Image 5.37a).
- Armour-piercing (AP, a hardened projectile) and APHC/APCR (armour-piercing hard core (US) or armour-piercing composite, rigid (UK)): a hardened, often tungsten, penetrator within a light alloy body.

HE and HEI types are employed against a range of targets including personnel, light vehicles, structures, and materiel. SAPHE and SAPHEI types are similarly multipurpose in nature, with improved effectiveness against light armoured vehicles and structures. AP and APHC are specifically used against armoured targets, primarily vehicles (ARES, 2017; Williams, 2000).

Light cannon cartridges fielded more recently include armour-piercing discarding sabot (APDS) rounds, which feature hardened, typically tungsten, penetrators, with discarding plastic sabots (see Image 5.37b); frangible armour-

Image 5.37 Selected light cannon ammunition

Note: (a) Two sectioned 20 × 128 mm cartridges showing the typical arrangement of SAPHE/SAPHEI (left) and HE/HEI (right) projectiles; (b) A sectioned APDS projectile, with an additional penetrator at left for comparison.
Source: Anthony G. Williams/ARES

piercing (FAP), which have tungsten penetrators designed to break up into high-velocity fragments after penetration; and penetrator with enhanced lateral effect (PELE), also lacking high-explosive contents, and designed to fragment after penetration. These projectiles are typically available in 20 mm cartridges. Larger calibre ammunition features additional types of projectiles (ARES, 2017; Ness and Williams, 2007; Williams, 2000).

Physical features

Most light cannon ammunition is similar to small-calibre ammunition, only larger; however, there are a number of key differences. Cannon projectiles rarely feature a jacket as they have separate driving or rotating bands which engage the barrel rifling to spin the projectile. These bands vary in number, location, material, crimping, and colour, and thus are often useful identification features. Typically, the bands are made of iron, plastic, or copper, and most commonly one or two such bands are present. The number of crimps at the mouth of the cartridge case is another useful diagnostic feature (see Image 5.38) (ARES, 2017; Williams, 2007).

Image 5.38 A Soviet 23 × 152B mm cannon cartridge

Note: This cartridge has double crimping at the case mouth, a copper driving band, and a silver-coloured nose fuse with pink tip marking.
Source: Confidential/ARES

Another notable difference between small-calibre cartridges and many medium-calibre cartridges is the presence of a fuse. In some light cannon ammunition, the fuse will be integral to the projectile and will not be externally visible. In other cases, however, the fuse will be externally visible and may be one of several types available for a given projectile. Fuses will have their own physical characteristics, including their composition, shape, and location. Fuses are generally fitted to the nose of the projectile, but some are located in the base or midsection.[123] Most are simple impact fuses, but time and proximity fuses are also in limited use (ARES, 2017; Williams, 2000).

Markings

Light cannon ammunition is typically marked in a similar way to small-calibre ammunition, but often features additional elements. Light cannon cartridges often feature a headstamp and/or case wall marking, as well as a tip colour code. NATO cannon projectiles are painted to reflect their nature. Standard NATO colours include yellow (HE), black (AP), and blue (TP—training/practice), with red bands or lettering to indicate a tracer or incendiary content. Externally visible fuses may also be marked. Russian projectiles are often not painted, and are usually differentiated by physical features (ARES, 2017).

Grenade launcher cartridges[124]

As noted above, grenade launchers fire a variety of relatively low-velocity projectiles that are sometimes referred to as 'projected grenades' (see Image 5.39).[125] Early models were of the simple high-explosive type, but high-explosive dual-purpose (HEDP) rounds have become much more common because their shaped-charge warheads are effective against some lightly armoured vehicles while retaining the ability to engage personnel.

123 For more information on types of fuses used with cannon ammunition, see also Dullum et al. (2017).

124 This section does not address cartridges developed primarily for riot control weapons, such as those in 37/38 mm calibre.

125 Grenade launchers typically use a high/low pressure system. The primer in the cartridge ignites the propellant contained within a small high-pressure compartment, from which gas is bled into a low-pressure compartment, accelerating the grenade gradually up the barrel. In some designs, both compartments are contained within the cartridge case; in other, semi-caseless designs the high-pressure compartment is in the base of the projectile, and the low-pressure compartment is essentially the chamber of the launcher (ARES, 2016a; Williams, 2017).

Image 5.39 Some sample cartridges used with grenade launchers

Note: (a) 40 × 46SR mm (40 mm NATO LV); (b) 35 mm DFS10 semi-caseless; (c) 40 mm VOG-25 semi-caseless; (d) 30 × 29B mm; (e) 35 × 32SR mm; and (f) 40 × 53SR mm (40 mm NATO HV).
Source: Anthony G. Williams/ARES

The militaries of NATO member states (and, increasingly, other states) typically employ 40 mm calibre ammunition (see Table 5.3). These rounds are generally divided into two common types: low-velocity (LV) and high-velocity (HV) cartridges. LV cartridges are generally used with under-barrel and shoulder-fired systems, which typically have a range of up to 400 metres. HV cartridges are generally used in belt-fed automatic launchers and have a range of up to 2,200 m (Williams, n.d.). Several companies offer additional types of 'uprated' ammunition, including:

- low-velocity extended-range (LV-ER) rounds, which have a range of about 600 metres; and
- medium-velocity (MV) rounds, which fire heavier and higher velocity projectiles out to some 800 metres (Williams, 2017).

LV extended range rounds can generally be fired from under-barrel launchers, while the more powerful MV rounds require a more substantial launcher, such as some six-shot revolver-type grenade launchers (ARES, 2017).

Table 5.3 Selected grenade launcher cartridges in global military service

Cartridge designation	Country of origin	Projectile type	Projectile weight (g)
43 × 30 mm	Russian Federation	Thermobaric	250
40 × 46SR mm	United States	HE	170
40 × 53SR mm	United States	HE	245
40 mm VOG-25	Soviet Union	HE	250
35 × 32SR mm	China (PRC)	HE	240
35 mm DFS10	China (PRC)	HE	170
30 × 29B mm	Soviet Union	HE	280
20 × 42B mm	South Africa	HEI	110
20 × 30B mm	South Korea	HEAB[i]	110

Note: All figures are approximations and vary according to cartridge type and loading, and other factors. [i] HEAB stands for 'high-explosive airburst'.

Sources: Jenzen-Jones and Popenker (2015); Poongsan (2016); Yan (2015); Williams (n.d.; 2016; 2017)

In former Warsaw Pact countries, other calibres dominate (see Table 5.3). Low-velocity cartridges for the Soviet/Russian 40 mm VOG-25 and Chinese 35 mm DFS10 are similar in performance to their NATO equivalents, but they are semi-caseless projectiles which are loaded from the muzzle. Both nations use conventional cased rounds for their longer-range HV systems (the Soviet/Russian 30 mm VOG-17 and Chinese 35 mm DF87) (ARES, 2017; Williams, 2017).

Several manufacturers have recently fielded grenade launcher rounds in new calibres and with new capabilities (see Image 5.40). Among the most notable are the programmable airburst rounds for the US XM25 (25 mm) and the Korean K11 (20 mm) weapons (see Box 5.1). Another round worth mentioning is the 43 × 30 mm thermobaric (see Box 5.3) cartridge for the Russian GM-94 grenade launcher. The cartridge is made almost entirely of polymer, which minimizes fragmentation and allows for use at very short ranges during combat in enclosed areas (Jenzen-Jones and Popenker, 2015, p. 7). The South African Denel PM iNkunzi PAW and Strike systems fire 20 × 42B ammunition that consists of standard 20 mm cannon projectiles fired from shorter cases at a subsonic velocity (ARES, 2017; Williams, 2017).

Perhaps the most significant development in ammunition for grenade launchers is the advent of small missiles that can be fired from standard under-barrel 40 × 46SR mm launchers. An example is the laser-guided Raytheon Pike, which has a range of 2,000 m, and was the first guided missile designed to be fired from an under-barrel grenade launcher (Raytheon, 2018; see Image 5.41).

Image 5.40 Examples of recent grenade launcher cartridges

Note: (a) 40 × 46SR mm (40 mm NATO LV; for comparison); (b) 20 × 30B K-11; (c) 20 × 42B iNkunzi; (d) 25 × 40B XM25; and (e) 40 mm Balkan semi-caseless.
Source: Anthony G. Williams/ARES

Image 5.41 The Raytheon Pike 40 mm guided missile

Source: Anthony G. Williams/ARES

Box 5.3 Common types of explosive warheads used in light weapons ammunition

At their most basic, explosive warheads are comprised of a fuse, an explosive fill, and a warhead case. Some of the key types of warheads are described below; there are many other more specialized types.[126]

Many light weapons make use of explosive warheads to deliver the desired effects on target. There are three primary ways an explosive weapon can cause damage: through blast, fragmentation, and heat (thermal effects).

High-explosive

High-explosive (HE) warheads are the most common type of warhead for most light weapons ammunition. HE warheads cause damage primarily through the blast wave that they generate, but also through fragmentation and, to a lesser extent, thermal effects. When fragmentation is desired, HE warheads may be constructed with a relatively heavy casing. When the warhead detonates, the casing breaks apart into small pieces, or fragments, which travel at high speeds away from the blast, causing kinetic (impact) damage to whatever they strike. HE warheads are used to engage targets of all types (Cross et al., 2016).

High-explosive fragmentation

High-explosive fragmentation (HE-FRAG) warheads primarily cause damage by generating high-velocity fragments and are employed against personnel and unarmoured vehicles. HE-FRAG warheads may rely on 'natural' fragmentation of warhead materials (which are sometimes brittle, such as cast iron or steel) or include pre-formed fragmentation (for example, steel spheres or cubes). In some cases, a 'fragmentation sleeve' (often a pre-scored piece of metal or a polymer matrix containing pre-formed fragmentation) is attached to the outside of a munition's body (Dullum et al., 2017, pp. 79, 83). Typically, fragmentation warheads use some 30 per cent of the energy from a detonation to disperse fragmentation, with the rest of the energy causing blast effects as described above (NSWC, n.d., p. 8). It is not always readily apparent whether a munition is an HE or HE-FRAG type; different users may classify similar rounds differently.

High-explosive anti-tank

High-explosive anti-tank (HEAT) type ammunition is designed to penetrate armour. Most HEAT warheads are 'shaped charges', meaning they feature a cone-shaped cavity that is lined with a thin metal sheet (typically copper). When the warhead functions, the metal liner collapses into a thin jet that travels at an extremely high velocity. The metal jet 'punches through' armour and penetrates into the target vehicle, causing injury to personnel and damage to the interior of the vehicle. HEAT ammunition is not particularly useful against personnel outside of vehicles since their casings are usually thin and fragmentation is comparatively minimal (Cross et al., 2016, pp. 22–23).

High-explosive dual-purpose

High-explosive dual-purpose (HEDP; sometimes called 'HEAT-FRAG') warheads are designed to provide both anti-armour and anti-personnel effects. Generally, this is achieved by pairing a HEAT warhead with a pre-fragmented (scored) casing or fragmentation sleeve.

Thermobaric

Thermobaric warheads contain certain explosive compositions that exploit oxygen in the air to generate blast effects that last longer than those of conventional explosives; they increase in duration from a few milliseconds to tens of milliseconds. The characteristics of these weapons make them suitable for use against targets in enclosed spaces, such as buildings, caves, or tunnel systems. Thermobaric weapons may be used to ensure sufficient blast effects for lethal use while minimizing or obviating fragmentation (Cross et al., 2016, p. 25).

126 For a basic overview of explosive munitions, see Cross et al. (2016).

Physical features

Ammunition for grenade launchers is designed for low chamber pressures and, as such, has certain distinctive characteristics. The rounds have thin walls and a relatively large explosive capacity, and are often made out of lightweight alloys, such as aluminium. Semi-rimmed (SR) and rimless designs are common. These rounds are generally fed into the grenade launcher via box or drum magazines, or belts. Belted cartridge cases are used with several grenade launchers. Belt-fed cartridges frequently feature projectiles that are larger than their cases, typically with rounded noses (see Figure 5.1).

Fuses are typically located inside the projectile but some impact fuses are fitted to the nose of a projectile. When the fuse is externally visible, its physical characteristics, including its material composition, shape, and where it is located, should be noted.

Figure 5.1 Some of the key physical features of grenade launcher ammunition

Note: In this case, the ammunition is a US 40 × 46SR mm M406 HE model.
Source: Jim Geibel via ARES

Some grenade launcher projectiles feature driving or rotating bands, which can serve as a useful identification feature, based on their location, material, crimping, and colour (see Image 5.42).

Other types of ammunition for grenade launchers include illumination and signal flares, smoke, anti-personnel, thermobaric, and less-lethal impact and riot control agent (RCA) rounds. Many are distinguishable by their physical features. Less-lethal impact rounds, for example, often have a spongy projectile, while most illumination cartridges have a substantially greater overall length than high-explosive rounds. Similarly, anti-personnel rounds often look like large metal-cased shotgun cartridges (ARES, 2017; Williams, n.d.).

Image 5.42 Two US M385 40 × 53SR mm practice cartridges in links, as used with belt-fed grenade launchers such as the MK 19 series

Note: This image shows the copper driving bands, different coloured metal finishes, and markings.
Source: Drake Watkins/ARES

Markings

Markings on grenade launcher ammunition, which are often stencilled, typically identify the manufacturer, functional type, year of production, and/or the lot or batch number (see Figure 5.2). While projectiles are frequently marked with an identifying colour scheme, manufacturers and users use a number of different formats. Some rounds have headstamps and/or additional markings on the cartridge case. Fuses also usually feature their own markings.

Figure 5.2 Sample markings on a Bulgarian Arsenal RLV-HEF-1 40 × 46SR mm HE-FRAG cartridge

Bulgarian GLV-HEF

GLV-HEF	Projectile model designation
[‘double-circle-ten’ symbol]-01-12	Manufacturer code (Arsenal JSCo., Bulgaria) – lot number – year of production (2012) (for projectile)
40×46 mm	Calibre (40 × 46SR mm)
RLV-HEF	Cartridge model designation
[‘double-circle-ten’ symbol]-01-12	Manufacturer code (Arsenal JSCo., Bulgaria) – lot number – year of production (2012) (for completed cartridge)

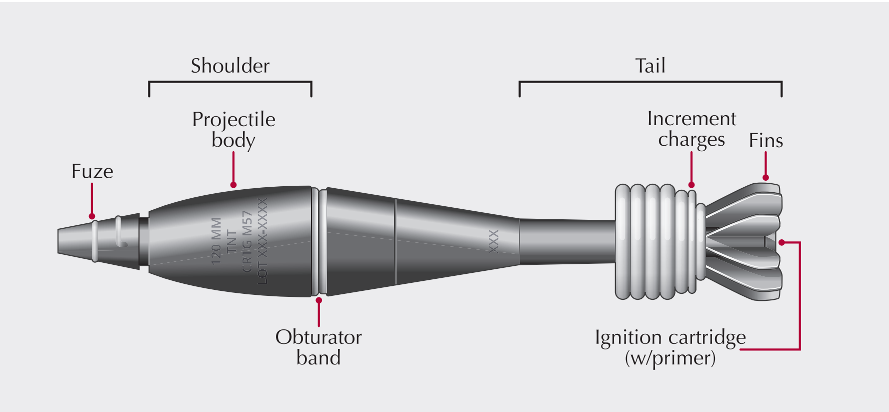
Source: Arsenal JSCo via ARES (n.d.)

Light and medium mortar projectiles

Mortar projectiles are traditionally simple designs that are very cheap to manufacture. They typically consist of a projectile, ignition cartridge, and (optionally) one or more auxiliary charges (see Figure 5.3). Most high-explosive rounds have cast iron or cast steel bodies, high-explosive fillings, and simple impact fuses (Jenzen-Jones and Paunila, 2017).[127] Other commonly available mortar projectile types include smoke (including white phosphorus), illumination, TP, incendiary,[128] guided, and cluster munitions. Guided projectiles are usually readily identified by complex, movable control surface assemblies and advanced fuses (see Image 5.43) (Dullum et al., 2017; ARES, 2017).

The typical mortar projectile is fitted with an ignition cartridge (sometimes known as a 'base charge' or 'propelling cartridge') that is either integral to the round or removable. The ignition charge features a primer similar to those used in small-calibre cartridges. The primer is located inside the tail of the round. When the round is dropped down the mortar tube, the firing pin at the bottom

Figure 5.3 Arrangement of a typical mortar projectile



Adapted from: US Department of Defense (2007)

127 In some cases, forged steel bodies are used; however, cast metals tend to produce more effective fragmentation for anti-personnel purposes (Jenzen-Jones and Paunila, 2017).

128 Incendiary weapons cause primary and secondary fires to destroy materiel. Incendiary ammunition for light weapons typically use solid incendiary compositions such as thermite, magnesium, and/or white phosphorus. Traditional liquid incendiary fills such as napalm or kerosene are generally not used in light weapons ammunition.

Image 5.43 XM395 precision guided mortar projectile

Source: Anthony G. Williams/ARES

of the tube impacts the ignition cartridge, detonating the primer, which ignites the propellant (Dullum et al., 2017). The expanding gases generated by the burning propellant push the projectile out of the tube and towards the target.

In some designs, the ignition charge alone can propel the projectile at a low velocity and is suitable for engaging targets at very close ranges. For longer range targets, the operator affixes a number of ring-shaped propellant charges to the projectile (Dullum et al., 2017, p. 28). These charges, which are called 'increments', 'propelling charges', 'auxiliary charges', or 'augmenting charges', are commonly attached to the tail of modern mortar projectiles, and to the fins of older rounds.

Recent improvements to mortar rounds include better materials, more aerodynamic designs (to achieve longer ranges), and more sophisticated fuses.[129] GPS conversion kits for 120 mm rounds are now available, and kits for light and medium mortar calibres are likely to follow. Purpose-designed guided mortar bombs have also been developed in 81 mm, with 60 mm likely to be fielded in the near future (Jenzen-Jones, 2015b; Williams, 2016).

129 The improvements to materials include bodies designed for more efficient fragmentation, the addition of pre-formed fragments, and the use of insensitive explosive fillings. See, for example, Williams (2016).

Physical features

The typical mortar projectile is widest behind the shoulder of the body and at the tail. Mortar projectiles must be slightly narrower in diameter than the bore of the weapon from which they are fired. They, however, also need to block some of the gas produced by the propelling charge, because if this escapes past the body of the projectile it reduces its range (ARES, 2017). The most common way of preventing these gases from escaping is to employ a series of 'gas check' bands that are cast or machined into the body. Some mortar projectiles are fitted with an obturator band (or obturating ring) instead of gas check bands. Obturator bands are often made of hard nylon (Jenzen-Jones and Paunila, 2017, p. 28). The number, location, and character of gas check or obturator bands are a key physical identification feature.

Image 5.44 A range of 60 mm, 81 mm, and 120 mm mortar projectiles

Note: 60 mm projectiles (L-R: smoke, HE, illumination) at left; 81 mm (L-R: illumination, smoke, HE) in foreground (all sectioned); and 120 mm projectiles (L-R: HE, smoke, illumination) at rear. Increment charges are present on all examples.
Source: Anthony G. Williams/ARES

The functional type of a mortar projectile can often be determined from its physical features. For example, many cargo (carrier) projectiles, such as certain smoke and illumination types, have a greater overall length, and a more cylindrical shape than conventional HE types (see Image 5.44). Mortar projectiles are almost invariably fitted with a nose fuse.[130] Fuses have their own physical characteristics, including distinctive shapes and components. Increment charges should also be documented since their composition, shape, type, and colour are often useful for identification purposes.

130 Most mortar rounds have impact fuses, but some have time or proximity fuses. Increasingly, multifunction fuses are being employed.

Markings

Mortar projectiles, like many other types of large-calibre ammunition, are typically painted in accordance with a specific colour marking scheme, often to indicate different functional types. Different armed forces and manufacturers use different colour schemes. The US colour marking scheme, which is similar to the scheme used by many NATO states and other allies, is presented in Box 5.4 (ARES, n.d.). Information about the functional type of the projectile is normally stencilled on the body. Other markings that indicate the manufacturer, year of production, and lot or batch number may also be present (see Image 5.45). Ignition cartridges, fuses, and increment charges may also be marked. Ignition cartridges (see Image 5.46) often have a headstamp visible at the base of the projectile. Fuses are generally marked to indicate model or type, and often bear other markings as well.

Image 5.45 Markings on a British L19A2 white phosphorous (WP) smoke 81 mm mortar projectile

Note: There is a colour-coded body, obturating band, and differing stamped and stenciled (painted) markings.
Source: Peter Bouckaert/HRW

Image 5.46 Markings on various ignition cartridges

Note: (a) Plastic body; (b and c) sealant-impregnated cardboard/paper bodies.
Source: Diehl and Jenzen-Jones (2012)

Box 5.4 US ammunition marking colour scheme

Munitions are painted primarily to inhibit the formation of rust, identify the functional type of the ammunition, serve as camouflage, or identify hazardous fillers. Some of the more common marking colours are presented in Table 5.4 (US DoD, 2009). It is important to note that schemes may be combined with a camouflage colour (typically olive drab) or other marking colours to indicate additional effects (for example, incendiary).[131]

Generally speaking, the US colour marking scheme outlined in Table 5.4 applies to ammunition in US service which is larger than 20 mm in calibre. US allies often use the same or similar marking schemes. While marking colour schemes provide important information about the round, it is important to identify ammunition by assessing physical features and markings as well.

Table 5.4 Selected marking colours on US ammunition

Colour	Ammunition type
Olive drab	No significance (camouflage purposes)
Yellow	High explosive
Brown	Low explosive
Grey	Chemical
Light green	Smoke
Light red	Incendiary
White	Illuminating (pyrotechnic)
Black	Armour-defeating
Aluminium (silver)	Countermeasure

Source: US DoD (2009)

131 For an expanded list, including details regarding the specific colouration of markings on the body, text, coloured bands, etc., see US DoD (2009).

Recoilless weapon projectiles

Projectiles for recoilless weapons vary significantly. This variation reflects:

- differences in the design and operation of reloadable versus disposable recoilless weapons;
- their many and varied battlefield roles; and
- developments in technology.

While the most common projectile types are high explosive (HE) and high explosive anti-tank (HEAT), a wide range are produced (ARES, 2017).

Recoilless weapons were primarily intended for use against tanks and other heavily armoured vehicles; rounds with warheads designed to penetrate armour (HEAT types) are therefore most common. Other projectiles are designed for use against personnel (HE/HE-FRAG), and buildings and other concrete structures (often known as anti-structure munition (ASM), and multipurpose (MP) warheads) (ARES, 2017).[132] Several ASM/MP warheads are able to penetrate walls before detonating inside a building. More advanced variants of both HEAT and ASM rounds have tandem warheads: the initial warhead blows a hole in the wall or armour, through which a second warhead enters the target before detonating.[133] Some recoilless weapons are able to fire a wide variety of ammunition types (see Image 5.47).

Some recoilless weapons fire conventional cartridge-based ammunition, while others use ammunition more similar in form to mortar projectiles or rockets. Rocket-assisted projectiles (RAPs), particularly those fired from disposable shoulder-fired systems, are sometimes readily confused with 'true' rockets, for example. Some recoilless projectiles feature an ignition cartridge and auxiliary charges similar to those used in mortar projectiles (ARES, 2017). Other types, particularly RAPs such as those fired from the RPG-7 series of weapons, are fitted with a type of propellant charge known as an expelling charge. This charge, which is fitted to the munition before it is fired (see Image 5.48), expels the projectile from the barrel of the weapon. When the projectile is a safe distance from the operator, a sustainer rocket motor ignites and propels the projectile towards the target (Jenzen-Jones, 2015c).

132 Multipurpose types are sometimes known as 'multi-target' (MT).

133 See, for example, Warwick (2008).

Image 5.47 A range of cartridges produced for use with the Carl-Gustaf shoulder-fired 84 mm recoilless weapon

Note: (a) HEDP; (b) ASM; (c) multi-target (MT–a term sometimes used instead of multipurpose); (d) HEAT; (e) tandem HEAT; (f) HEAT; (g) TP; (h) smoke; (i) illumination; (j) anti-personnel (APERS); (k) HE; and (l) training/practice–tracer (TPT). Some cases are marked to indicate RAPs.
Source: Anthony G. Williams/ARES

Image 5.48 Bulgarian PG-7 projectiles in the process of being assembled

Note: The image shows the expelling charge cases (see also Image 5.53), thread protectors, and other packaging.
Source: Confidential/ARES

When a recoilless weapon is fired, high-velocity exhaust gases exit the weapon from the rear of the gun. The energy generated by these gases must be released in order to counteract the recoil of firing the weapon. The gases, which are often readily observable by the enemy as they kick up dust and debris, can injure personnel and damage objects behind the weapon; such weapons cannot therefore be fired from inside enclosed spaces. To overcome this issue, some recoilless weapons expel a liquid, shredded material, or powder instead of high-pressure gas. These weapons are generally known as confined space (CS) variants because they can be used in confined spaces (the user can fire the weapon out of a window from inside a room, for example) (ARES, 2017; Jenzen-Jones, 2015c). Some of these systems may leave evidence of their firing on the battlefield in the form of the expelled material.

Physical features

Some recoilless weapons fire cartridge-based ammunition similar in form to other cartridges, including small-calibre ammunition. These rounds often comprise a cartridge case, projectile, primer, and other features seen on other cartridge-based ammunition. Case type, case shape, and case and projectile composition should all be noted.

A careful examination of a recoilless projectile's physical features can often reveal much about the projectile. Certain projectiles with tandem warheads, for example, are readily distinguishable from conventional high-explosive types by their distinctive profile (see Image 5.49). Driving and rotating bands on some recoilless projectiles also serve as useful identification features. The location, material, crimping, and colour of these bands varies from model to model. Most commonly these bands are made of copper, iron, or plastic.

Propellant charges, including expelling charges, may also be encountered and can often be used to identify a model of weapon in the absence of other evidence. For example, the propelling charge in Image 5.50 would suggest the RPO series of recoilless projectiles, which is commonly encountered in certain conflict zones.

Recoilless projectiles are frequently fitted with an externally-visible fuse in the nose of the projectile, most commonly an impact fuse, but occasionally a time or proximity fuse. Fuses have their own distinctive physical characteristics, including where they are located on the weapon, their material composition, and their shape.

Some types of recoilless projectiles are difficult to distinguish from other types of ammunition, such as mortar projectiles and rockets. Certain Eastern Bloc recoilless projectiles, for example, closely resemble mortar projectiles (see Image 5.49). Similarly, some recoilless projectiles fired from disposable, shoulder-fired weapons share physical characteristics with rockets fired from similar weapons (see Image 5.50). Finally, certain recoilless projectiles can be fired from vehicle-mounted launchers, with only minor modifications.[134]

Image 5.49 Soviet BK-881M type 82 mm recoilless HEAT projectile

Source: US Department of Defense

Image 5.50 An early Soviet RPO-A shoulder-fired 93 mm recoilless weapon showing the projectile and distinctive propelling charge below the gun

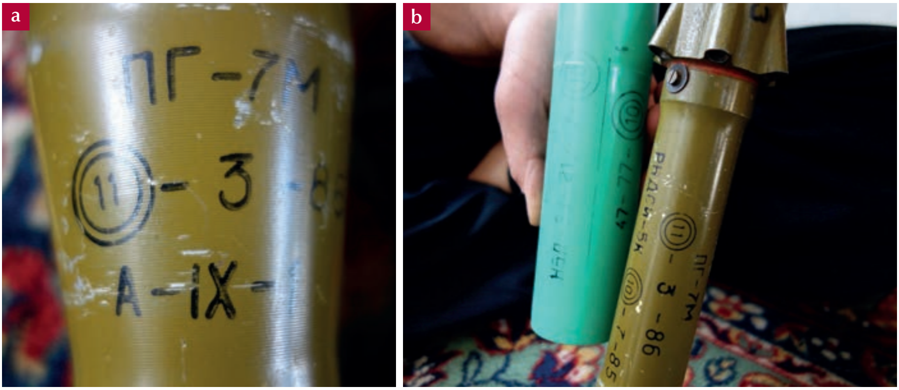
Source: Wikimedia Commons/Magapixie

134 For example, some recoilless projectiles fired from light weapons such as the SPG-9 are identical or nearly identical in form and function to those fired from smooth-bore 73 mm guns fitted to armoured vehicles, such as the 2A28 Grom. In some cases, the same projectile may be fitted with different expelling charges depending on the weapon it is being fired from (IDA, 1995).

Markings

Markings on recoilless projectiles often reveal the functional type, manufacturer, year of production, and the lot or batch number (see Image 5.51 and 5.52). The markings on the body of the projectile are often stencilled. The colour of these markings often indicates the functional type of the projectile. Fuses are generally marked in a similar way to indicate mode or type. Expelling charges, ignition cartridges, and increment charges may also feature markings indicating their model, type, propellant, year of production, and other details (see Box 5.5).

Image 5.51 Markings on a Bulgarian PG-7M projectile for the RPG-7 series of shoulder-fired recoilless weapons



Note: (a) Markings in this case include the designation ('PG-7M'), factory code ('double-circle 11'), lot number ('3'), year of production ('86'), and composition of the explosive fill ('A-IX-1'). (b) Further markings on the same projectile with information about the projectile and the rocket motor which assists in accelerating it. Markings are also visible on the PG-7P expelling charge (left), in a similar format.
Source: C.J. Chivers/*The New York Times*

Image 5.52 Markings on the base of a 106 mm HESH cartridge case

Note: There are three distinct sets of markings: a 'conventional' headstamp, stamped into the material of the cartridge case itself; painted markings giving the most critical data; and markings stamped onto the primer.
Source: Confidential/ARES

Box 5.5 RPG-7 projectile designations

Projectiles designed by producers in the Soviet Union, the Russian Federation, and many other former Eastern Bloc countries typically have a 'V' in the designation (for example, PG-7V, PG-7VR, etc.); this stands for *vystrel*, or 'round', which refers to the combination of the projectile and the expelling charge.[135] The expelling charge, sometimes referred to as a 'booster section', launches the projectile out of the barrel. When the projectile is at a safe distance from the operator, the rocket sustainer motor kicks in, accelerating the projectile towards its maximum velocity. Hence 'PG-7,' refers specifically to the projectile alone, while 'PG-7V' refers to the round in its entirety including the expelling charge (in this case, PG-7P, see Image 5.53), whether assembled or not (Jenzen-Jones, 2012b).

Image 5.53 PG-7P expelling charges for the RPG-7 shoulder-fired recoilless weapon

Note: Markings indicate manufacturer, date of production, lot number, and other details.
Source: Confidential/ARES

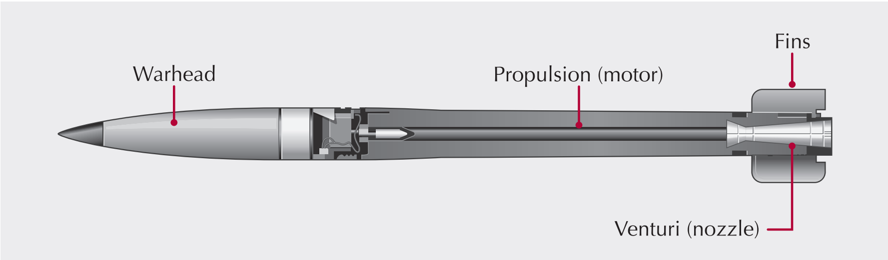
Unguided rockets

Rockets vary significantly in size, range, technological sophistication, and role. In its simplest form, a rocket consists of a tube in which fuel is burned, with an opening at one end. The escaping gases cause an equal and opposite reaction on the closed end of the tube, propelling the rocket forwards (Ryan, 1982).

Rockets in common usage are either spin-stabilized or fin-stabilized. Spin-stabilized rockets are generally of a shorter overall length than their fin-stabilized counterparts. Spin is achieved through a series of obliquely-mounted nozzles placed off-centre at the rear end of the rocket. Fin-stabilized rockets also rotate

135 In other ammunition types, components of a 'round' may also include propellant, cases, wadding, and/or other items.

Figure 5.4 Arrangement of a typical fin-stabilized rocket



Adapted from: Dullum (2009)

but at a much slower rate (only a few revolutions per second). Most fin-stabilized rocket designs feature wrap-around or fold-out ('pop-out') fins which deploy a few metres after launch (Dullum et al., 2017, p. 31; see Figure 5.4). Unguided rockets are sometimes known as free-flight rockets (FFR). There are a wide variety of warheads for rockets, although HEAT, HE, and cargo types are most common.[136]

Physical features

For identification purposes, the key features of rockets include the following:

- The general dimensions, especially the diameter at the widest point of the body.
- Visible seams between the warhead and motor sections.
- Size, type, and number of fins.
- Rivets, bolts, welds, or other joining features.
- General profile of nose ogive.
- Visible exhaust ports (venturi) and other protrusions.

All of these features should be examined and recorded.

Externally-visible fuses are another important feature. Rockets have impact, time, or proximity fuses depending on their functional type and purpose. Some multifunction fuses are in service. Fuses have their own physical characteristics, including their composition and shape, and location.

136 Cargo munitions carry their payload to the target location and then control its dispersal. Cargo warheads may carry submunitions (which can themselves be HE, HEI, HEDP, etc. types), illumination candles, smoke units, propaganda leaflets, or other payloads. Cargo munitions most often use a time fuse.

Markings

Markings on rockets are often stencilled on the side of the body. The markings often identify the make, model, and type of rocket, as well as the year of production, lot or batch number, and safety information (see Image 5.54). Some rockets are marked in a certain colour to indicate functional type. Fuses, where present, will generally be marked to indicate model or type, and often bear other markings as well.

Guided missiles

As noted above, there are two primary and very different families of guided missiles fired from light weapons, which are employed for different battlefield roles: anti-armour or anti-aircraft. Anti-aircraft missiles (known as MANPADS when light weapons) have a much harder task, needing to accelerate to super-

Image 5.54 Markings on an Iranian 107 mm rocket and another rocket's inner packaging

Note: The markings identify the type of round (HEI), diameter (107 mm), date of production (2007), lot number (6), net weight (19.250 kg), and registration numbers (0185 and 186). Note also the distinctive colour markings, including the red band signalling an incendiary fill.
Source: Israel Defense Forces

sonic velocity quickly in order to hit very fast-moving targets. Wire guidance is not an option. Manual radio guidance has been tried but proved unsatisfactory in combat. Most MANPADS rely on infrared seekers.

The earliest ATGMs were low-speed rockets guided manually through wires which unwound from the missile as it flew. Since then, ATGMs have become significantly more sophisticated, with guidance systems that only require the operator to keep the sights trained on the target (the missile automatically follows the line of sight). Increasingly, ATGMs use wireless communication to transmit guidance commands. Some missiles are designed to fly a couple of metres above the line of sight and fire their warheads at a downwards angle to penetrate the much thinner top armour of armoured fighting vehicles. ATGMs most commonly feature HEAT warheads; however, so-called anti-structure munition (ASM) and multipurpose (MP) warheads are increasingly being introduced (ARES, 2017).

Physical features

Guided missiles are typically rather easy to identify. There are a relatively small number of systems in existence and most have a distinctive appearance. While the specific make and model are not always readily apparent, the pattern and capability of a weapon can usually be easily determined. Many ATGMs and MANPADS are readily distinguishable from other types of light weapons and from other guided missiles, due to their particular shapes and sizes, and frequently clear markings. Most portable guided missiles are contained within launch tubes which protect them while in transit and storage. ATGMs and their launch tubes tend to be comparatively short and fat, whereas MANPADS need to have a small (aerodynamic) frontal area to achieve high speeds, and so are relatively long and slim. Fins, most of which either fold out or wrap around the missile body, vary substantially from model to model; this makes them useful for identification purposes.

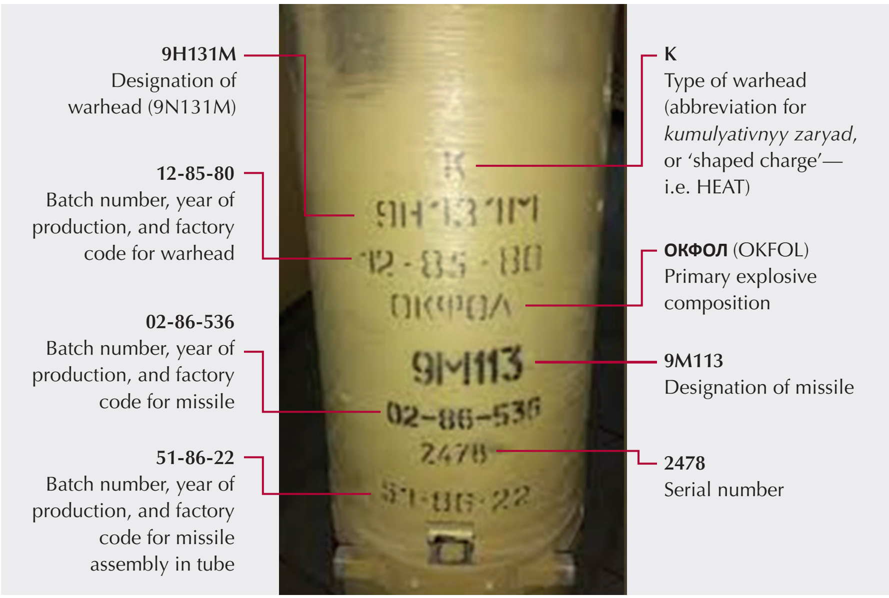
Markings

Markings on missiles for MANPADS and ATGMs are often stencilled on the side of both the missile and the launch tube. Markings usually indicate the make, model, and type of missile, as well as the year of production and lot or batch number (see Image 5.55 and Figure 5.5). Many missiles are also marked with a unique serial number, which can be particularly useful for tracing purposes.

Image 5.55 Examples of markings on ATGMs

Note: (a) Russian 9M131 missile for the 9K115 Metis (AT-7) ATGW. (b) Markings on a 9M14M Malyutka ATGM.
Source: Peter Bouckaert/HRW

Figure 5.5 Markings on a Russian 9M113 Konkurs ATGM



Source: Fulmer, Jenzen-Jones, and Lyamin (2016)

Packaging and documentation

As with small arms, many light weapons are encountered in the field with packaging and, to a lesser extent, documentation. There are two types of packaging: outer packaging and inner packaging. Outer packaging typically consists of wooden or plastic shipping crates (see Image 5.56) or plastic or metal storage containers. Inner packaging includes storage tubes, plastic packaging, and grease-proof paper.

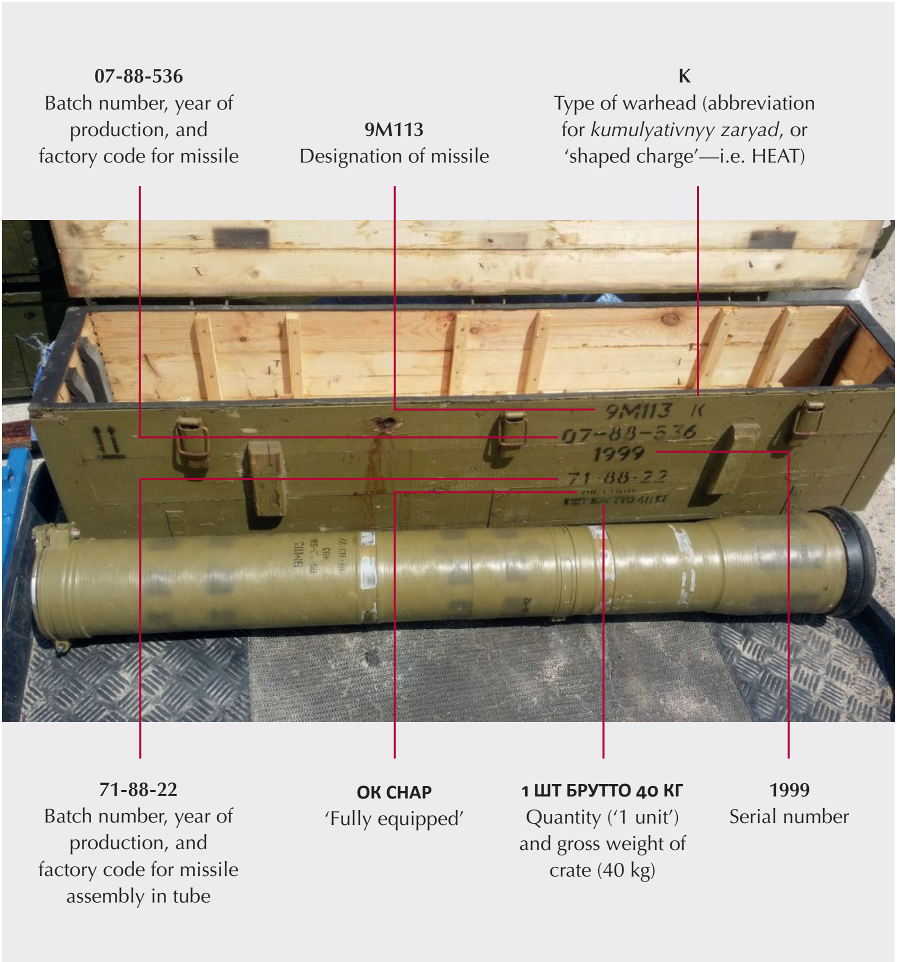
Image 5.56 External packaging crates and internal packaging tins containing Russian 14.5 × 114 mm B-32 API cartridges produced in 1989

Source: ARES (n.d.)

Packaging often provides valuable clues as to the origin, date and place of production, and type of the arms in question (see Figure 5.6).

Packaging may also reveal the destination, ports of transit, dates of transfer, and other important information about the transfer and chain of custody of the weapon. Image 5.57, for example, shows a crate with markings indicating the intended port of delivery ('Tripoli, L.A.R.'), unique case number ('Case No. 695'), and total number of cases ('No of Cases: 16667').

Figure 5.6 Markings on outer packaging for a Russian 9M113 Konkurs ATGM



Source: Fulmer, Jenzen-Jones, and Lyamin (2016)

Image 5.57 External packaging containing Yugoslavian M72 81 mm mortar projectiles with fuses

Source: Peter Bouckaert/HRW

Image 5.58 Packing list attached to the inside of a wooden crate containing Russian PG-7 projectiles and PG-7P expelling charges

Source: Confidential/ARES

Image 5.59 Deliberately mislabelled crate marked 'Parts of bulldozer', actually containing an artillery rocket manufactured in North Korea

Source: Peter Bouckaert/HRW

Crates of illicitly-exported weapons are sometimes deliberately mislabelled to conceal their actual contents. Image 5.59 shows a packaging crate labelled 'Parts of bulldozer' that actually contained a rocket. The crate was exported to Libya in violation of a UN embargo on arms transfers from North Korea. Mislabelling weapons crates is a common practice among traffickers of North Korean weapons and arms exporters located in other embargoed countries (Jenzen-Jones and Noakes, forthcoming).

Packaging for light weapons ammunition is often very useful for identification purposes, particularly when the ammunition (or the corresponding weapon) is no longer present. Most packaging follows the pattern established for small arms ammunition, though due to the size and robust nature of most light weapons ammunition, these items are often packaged in sturdier crates. Some more expensive, comparatively delicate types of ammunition, such as missiles, are packaged in containers with padding or other protective material.

Some types of ammunition are frequently found belted or otherwise ready for immediate use. For example, 40 × 53SR mm projectiles are almost exclusively fired from belt-fed AGLs and so typically come linked together. Many guided missiles are similarly provided ready to fire, and packaging containing such ammunition may be marked with 'fully equipped', 'completely loaded', or similar wording (see Figure 5.6 and Image 5.60). Projectiles and expelling charges for the RPG-7

Image 5.60 Wooden outer packaging (shipping crate) containing two 9M32M type MANPADS

Source: Peter Bouckaert/HRW

Image 5.61 Markings on a Bulgarian PG-9P expelling charge for projectiles fired from the SPG-9 recoilless gun

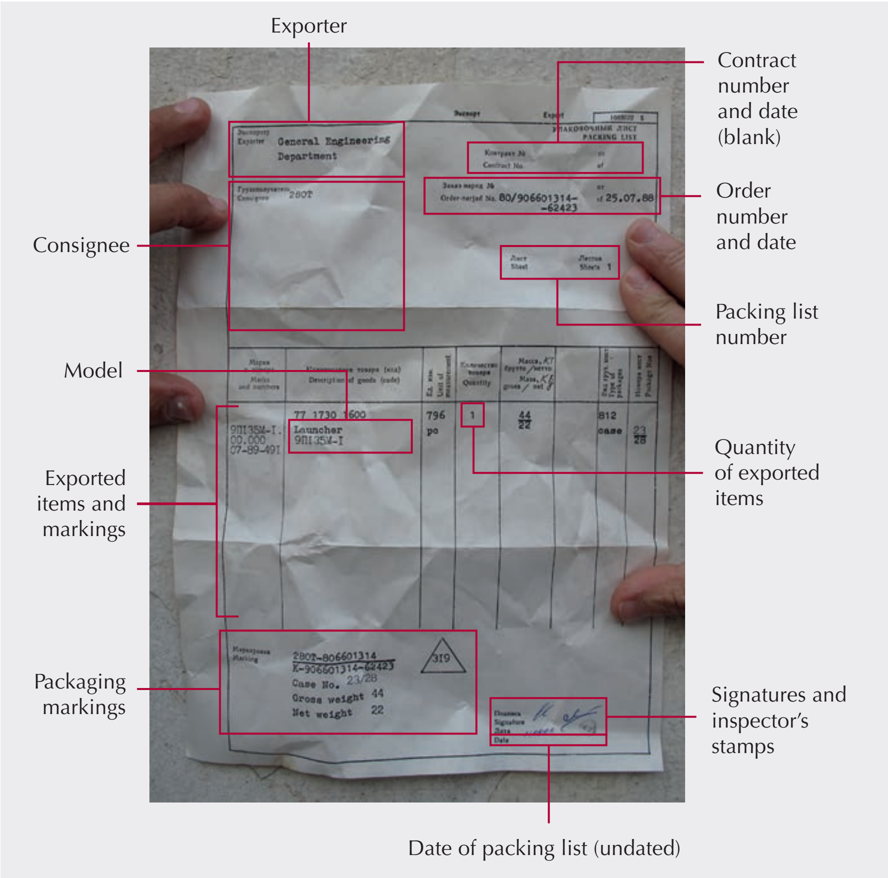
Source: Peter Bouckaert/HRW

and similar weapons are frequently unpacked, assembled, and carried as complete rounds, and thus the potentially useful packaging is often left elsewhere (see Image 5.48 and 5.61).

It is also important to note that smaller, seemingly inconsequential items, such as expelling charge cases and warhead thread protectors for RPG-7 rounds, may be left behind by operators who systematically collect other evidence. These operators may be unaware of the potential utility of these items for identifying weapons and ammunition. Such items are particularly important where light weapons are uncommon, for example in a domestic law enforcement environment; in conflict zones they may be so numerous that they are of comparatively limited use.

Documentation is one of the finest sources of information uncovered in the field. Import, export, or in-country transfer documentation often reveals key information not only about individual weapons but also about the shipments of which they were a part. This information includes contract dates, order quantities, ports of transfer, and country of origin (see Figure 5.7 and Image 5.58).

Figure 5.7 Delivery documentation (packing list) for 9P135M-1 ATGW launchers delivered to Libya in the late 1980s



Note: The authors of the document have used deliberately vague details.
Source: Confidential via ARES

— Authors: N.R. Jenzen-Jones with Jonathan Ferguson and Anthony G. Williams