TELESCOPED AMMUNITION: A FUTURE LIGHTWEIGHT COMPACT AMMUNITION?

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The concept for telescoped ammunition first came about at a US Air Force laboratory in 1954.[1] Telescoped ammunition is a form of gun ammunition in which the projectile is recessed into the main body with the propellant. While this type of round has several advantages over conventional gun ammunition, engineering challenges have so far prevented its implementation as a military ammunition. Recently, telescoped ammunition has been identified as a means of getting 30% more capability for a given size of ammunition or a 30% size reduction for the same capability.[2] More importantly, the technology is beginning to reach a usable maturity. Amongst various NATO allies, telescoped ammunition is being looked at for future medium calibre cannons through to light weight small arms ammunitions. This article examines both cased and caseless varieties of telescoped ammunition to give a better understanding of the technologies and to make recommendations on potential for use within the Canadian Land Forces.

Figure 1: Conventional vs Telescoped[22]

Telescoped Ammunitions

Telescoped ammunitions have been developed for a number of reasons. When first conceived, by the US Air Force, the goal was to produce much higher muzzle velocities in comparison to conventional ammunition. Since this time there have been several examples of developmental systems employing the technology in order to increase lethality or reduce bulk and weight. Telescoped ammunition has been used in experimental small arms, such as the H&K G11 and the Styer Advanced Combat Rifle, both of which were intended to increase the lethality of infantrymen.[3] In order to improve the lethality of its jet fighters, a USAF project to develop new compact fighter cannon produced the GUA-7 25 mm cannon based on telescoped ammunition.[4] Technical challenges prevented any of these weapon systems from being fielded. The weapon system to most closely reach successful implementation with telescoped ammunition has been a United States Marine Corps effort to develop a 75 mm telescoped ammunition for its LAV-25 family of vehicles[5].

Today, it appears that telescoped ammunition has finally developed to the point where it is ready for war: Mauser has developed a family of 30 mm and 35 mm telescoped ammunition-based recoilless cannons that it is ready to market,[6] The French and British joint venture known as CTA International has developed a 40 mm telescoped ammunition and cannon that is under assessment for use on the UK Warrior Armoured Fighting Vehicle (AFV); and the United States Joint Services Small Arms Program has selected two types of telescoped ammunition for the future Lightweight Small Arms Technologies (LSAT) program.[7]

Unlike conventional ammunition, in which the projectile protrudes out the front of the round body, telescoped ammunition has the projectile fully recessed into the body of the round. Telescoped ammunition exists in two varieties: Cased Telescoped Ammunition (CTA) and Caseless Telescoped Ammunition (CLA). Both types are fully cylindrical and operate on a system with a rotating chamber and a straight-through ejection system in which the next round pushes the previous out as it is loaded into the chamber. In order to get a better understanding of the characteristics of CTA and CLA, each will be examined individually.

Cased Telescoped Ammunition (CTA)

CTA has been described as "conventional technology in a telescoped configuration."[8] Just like conventional ammunition; CTA consists of a casing filled with propellant which is fired through a mechanical primer at the base of the round. However, despite the label of "conventional technology," CTA does differ from traditional ammunition. In an effort to reduce weight, CTA make use of materials other than brass or steel for casing construction. Options include lighter metals such as aluminum, semi-combustible cases or polymers. These same technologies are being applied to conventional cased ammunition, but the nature of CTA allows even more material strength to be sacrificed for a reduction of mass.

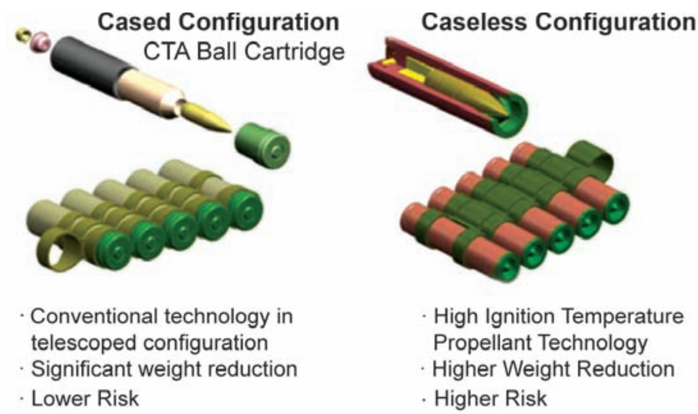

Figure 2: US LSAT 5.56 mm machinegun ammunitions in CTA and CLA configurations[23]

Because CTA operates by a straight-through ejection, the case does not require an extraction groove at the base and the case is perfectly cylindrical. Elimination of the extraction groove simplifies the design of all casings and, in small arms ammunition, allows for the use of materials which would lack the strength required for extraction without failure. Polymer cases for conventional ammunition require metal bases in order to survive the stresses of being used.[9] The CTA ammunition of the US LSAT program is able to employ a polymer-only case. The effect is that lightweight CTA casings can have less mass than comparable lightweight conventional cases.

While lightweight casings allow CTA to be produced with a lower mass than conventional ammunition, it is advances in propellant that allow CTA to be built smaller than conventional ammunition. One of the inventions that came from the American CTA was consolidated propellants.[10] Using this technology, designers can get a 30% volume reduction for the same number of grains of propellant.[11] Compaction of propellant grains at room temperatures only results in a limited increase in grain density and attempts to compact further will result in grain fracture and impaired ballistic performance. But, greater compaction is achieved with thermally consolidated propellants in which a thermal coating is applied to propellant grains and compaction is done while heated. In this process the melted coating acts as a lubricant and propellant grains will undergo minor deformation without fracture. When cooled, the thermally consolidated propellant retains a single rigid structure as a result of the coating. On combustion, the propellants "deconsolidate" and function as individual grains.

Two types of thermal coatings exist: energetic thermoplastics and inert coatings. Both types are rigid when cooled to temperatures at which military ammunition is stored and carried, but are liquid when heated too much higher temperatures. Inert coatings are used in

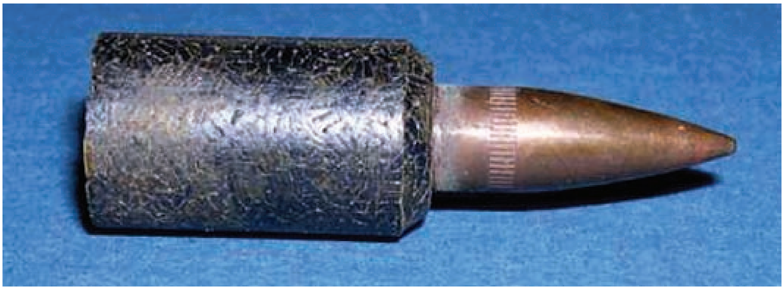

Figure 3: 5.56 mm Consolidated Propellant Caseless Ammunition[24]

order to delay or inhibit ignition of the propellant.[12] This can be helpful in developing two stage propellants in which some portion of the total propellant ignites at a later stage of firing. As will be seen later, this characteristic is helpful in resolving one of the challenges related to telescoped ammunition.

Despite the ability of consolidated propellants to occupy less volume, fitting both the projectile and the ammunition inside the casing has typically resulted in CTA having an increased diameter over conventional casings. One means of avoiding this increased diameter is to go with a completely caseless ammunition.

Caseless Telescoped Ammunition (CLA)

CLA consists of a body formed of propellant, an external protective coating, a standard mechanical primer and a booster to give full ignition. CLA is distinct from other caseless ammunitions because the projectile is fully recessed into the body. Current CLA ammunition is fully cylindrical, but this has not always been the case. In 1971, NATO held a series of trials to select a new standard small arms ammunition and one of the competing options was the German G11 rifle which fired a rectangular 4.73 mm CLA ammunition. While the G11 and its ammunition failed the NATO trials, this was probably the first example of a CLA. However, development continued after the trials[13] and improved G11 ammunition became the baseline from which many modern CLA programs are building (including the US LSAT).

The leading cause of the caseless ammunition's failure at the NATO trials appears to have been "cook-offs." The technical solution to this problem was the development of an improved propellant known as High Ignition Temperature Propellant (HITP). HITP is primarily

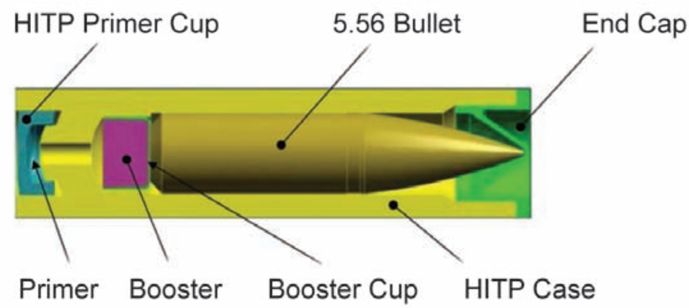

Figure 4: 5.56 mm CLA round for US LSAT program[25]

composed of cyclotetramethylenetetranitramine (also known as High Molecular weight RDX or HMX). The HITP is a more inert munition than nitrocellulose based propellants and so it can better stand the high chamber temperatures of a weapon that has been engaged in firing. The cost of this inertness is that CLA requires a booster charge in order to initiate the propellant. Structural integrity is enhanced by coating the formed HITP body with the same energetic thermoplastics used in the creation of consolidated propellants. The end result is that CLA is much lighter but less durable and more complex than CTA or conventional ammunition.

Weapon and Firing Mechanisms

The typical cylindrical shape of CTA and CLA allows for a unique chamber design and loading system. Typically, telescoped ammunition operates through a rotating chamber. A round is forced into the chamber which is then rotated in line with the barrel for firing. After firing the chamber is rotated back to the load position. Used casings or chamber debris are pushed out the front of the chamber by the next round being forced into the chamber rear. In larger AFV cannons, this method can be used to eject casings out the front of the turret and thereby eliminates the concern of handling hot casings inside of the turret.

Several mechanisms exist which create this moving chamber and straight-through eject. The G11 rifle[14] and Warrior 40 mm cannon designs are based on a chamber rotating on an axis perpendicular to the axis of the barrel. These mechanisms are shown in figures 5 and 6.

The US LSAT machinegun employs a chamber that rotates about an axis parallel to the barrel. From the load position, the chamber will rotate up to the barrel where it will lock in place to fire. On firing, the propellant gasses force the chamber to rotate back to the load position where the next round forces the casing out There is also the potential to employ multiple chambers, around an axis parallel to the barrel, for an increased rate of fire. This configuration would resemble a revolver in which one chamber is in the firing position aligned with the barrel while another chamber is in the load position. The maximum number of chambers would be limited by the size and weight available to the design. The Mauser RMK 30 mm cannon employs this multi-chamber revolver configuration.[15]

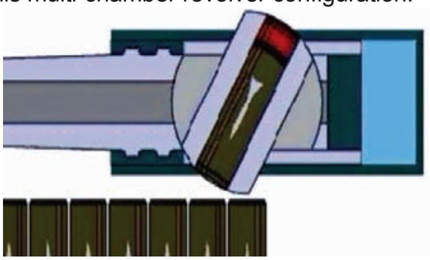

Figure 5: Warrior 40 mm CTA mechanism[26]

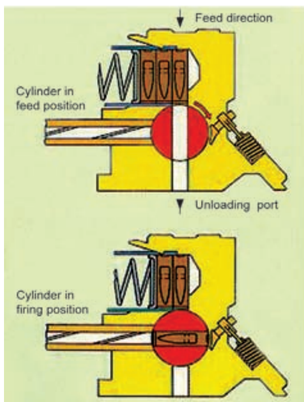

Figure 6: G11 mechanism[27]

While the overall principle of a rotating chamber remains the same for CTA and CLA, there is one significant difference related to the two types of ammunition. CTA provides for its own obturation at the back of the breach, but CLA does not. Therefore, the CLA weapon must include a mechanism to prevent propellant gas escaping rearward from the chamber.

The chamber sealing mechanism adds additional weight to the weapon but not necessarily to the combined weight of the weapon and ammunition.[16]

Engineering Concerns with Telescoped Ammunition

The engineering concerns related to telescoped ammunition primarily revolve around two issues: ballistic inefficiently and high barrel erosion.

Ballistic Inefficiency. A 1996 US DoD report identified many of the challenges that exist with the creation of cased telescoped ammunition. The principle of these challenges was that telescoped ammunition is ballistically inefficient when compared to conventional ammunition. The inefficiency is that for any given calibre projectile, telescoped ammunition requires a greater mass of propellant in order to achieve the same muzzle velocity. This is expressed as the ratio of muzzle velocity to propellant mass.

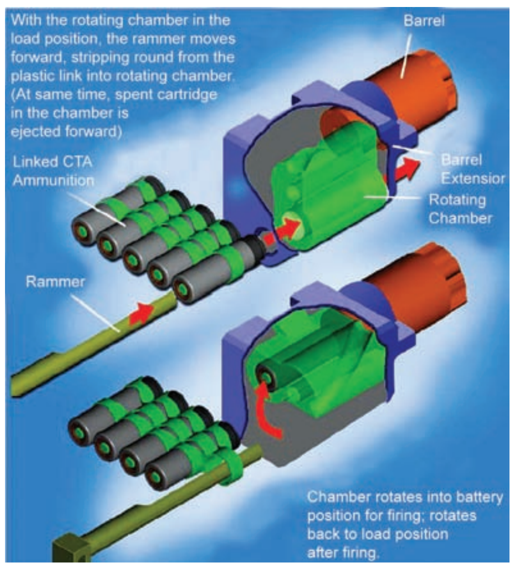

Figure 7: US LSAT Machinegun mechanism[28]

The principle cause of ballistic inefficiency, as identified in 1996, is gas blow-by that occurs as the projectile moves from the body of the round into the forcing cone where it achieves obturation of the barrel.[17] In order to prevent or limit gas blow-by in CTA, the projectile must move forward in near "perfect alignment with the axis of the barrel." To mitigate the effects of gas blow-by, some telescoped ammunition employs two stage propellants. The initial stage of propellant is packed entirely behind the projectile or at least entirely in the rear half of the casing. This initial stage of ignition pushes the projectile forward into the forcing cone. The second stage propellant is packed around the projectile and throughout the forward half of the casing. It is more inert and initially limits gas blow-by of the first stage propellant, then ignites as chamber pressures and temperature rise from the burning first stage propellant. It is unknown whether current generation telescoped ammunition has adopted fully effective mechanisms to improve obturation[18] around the projectile or if the increased propellant mass has been seen as an acceptable trade-off given the even greater reductions in casing mass and overall ammunition size.

Barrel Wear and Erosion. The increased mass of propellant used in telescoped ammunition results in greater peak pressures and greater heat generation, and this in turn transfers more heat to the weapon. At greater temperatures the barrel is more susceptible to increased barrel wear and ablation during firing. This results in significantly reduced barrel life in telescoped ammunition weapons. The solution was the development of an erosion inhibitor that is near the mouth of CTA. Erosion inhibitors consist of a paste that coats and protects the barrel from heat and chemicals during firing.[19] Despite having been developed for CTA, erosion inhibitors have gone on to be used in conventional ammunitions such as the M919 25 mm APFSDS-T.[20] The down-side of erosion inhibitors is that they reduce muzzle velocity slightly and increase the cost of the ammunition.[21]

Introduction of Telescoped Ammunition

Despite their engineering challenges, CTA and CLA ammunitions offer the potential for improvements over in-service conventional ammunition. However, the selection of one type of telescoped ammunition over the other will be dependant on the operational requirements of the weapon that it will be used in.

The trade-offs between the two types of telescoped ammunition are robustness and weight: the casing makes CTA more durable while the lack of a casing makes a CLA weapon system (with its ammunition) lighter. The relevance of this trade-off can be seen by comparing ammunition suitable for an AFV compared to that suitable to an aircraft. The 25 mm turret currently in Canadian service provides only limited room for ammunition. In the event that Canada decides to upgrade the cannon, telescoped ammunition would provide a means to do this within the available space. Within the vehicle, minimizing weight is less of a concern. As a result, the more robust CTA is an appropriate option for upgrading the cannon of an existing AFV. In aircraft, minimizing weight is of far greater importance and the ammunition is less likely to be exposed to rough handling. As such, CLA would be the more attractive option for an aircraft.

An additional characteristic which must be considered is the maturity of the technology. CTA uses more conventional technology and so it introduces the least risk in development of a new weapon. CLA remains the less mature of the telescoped ammunition. Therefore, CTA may be the default option when time and resources are most limited toward the development of a new weapon system. This increased risk has been recognized by the US military. The development of a LSAT machinegun has taken two parallel approaches with near identical designs being developed for both CTA and CLA guns.

Figure 8: Cut-away of 40 mm CTA being considered for the Warrior upgrade[29]

Despite the fact that no such ammunitions appear to have been produced for operational fielding, telescoped ammunition is a technology that is ready for introduction in operational military weapon systems. CTA and CLA both offer size and weight improvements over conventional ammunitions. CTA and CLA each come with their respective strengths and weaknesses, but this only serves to provide flexibility when selecting ammunition that meets the needs of the weapon under development.

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Figure Endnotes

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