WHY BULLPUPS?

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During the Second World War it became obvious that the bolt-action rifles used as standard by all armies except the USA were obsolescent. In fact, the German StG 44, which was in widespread service by the end of the war, emphasised the advantages of automatic as well as semi-automatic fire. The logic of this led several countries to copy the German approach and develop less powerful cartridges generating less recoil, to permit more controllable automatic fire.

Such an automatic rifle could also fulfil the role of a sub-machine gun, except for its excessive length. The British were therefore attracted to the idea of a rifle which was made much shorter than standard (while retaining the same barrel length) by mounting the action far back in the stock, which would enable it to replace the SMG as well as the rifle: this is known as the "bullpup" layout. Bolt-action rifles of this type had been made as early as the 19th century, and it seems that the name "bullpup" was applied to such guns in the USA in the 1920s, although the exact origin is obscure.

The first serious attempt to apply the bullpup layout to a selective-fire military rifle was the British 7mm EM-2 of the late 1940s, which got as far as being formally adopted for the British Army in 1951 before this decision was reversed following a change of government. NATO's adoption of the too-powerful American 7.62 x 51 cartridge put this idea into abeyance for some time.

The British 7mm EM-2 rifle

During the 1970s it became clear that NATO was going to select a new, lower-powered cartridge to supplement the 7.62 x 51 rifle/MG round. It was accepted by most that the American 5.56 x 45 round would be chosen, as this had been in US service for over a decade already, so a number of new rifles were designed around this cartridge.

Some of them were bullpups: the British produced what became the **SA80** family (principally the **L85** rifle and **L86** light support weapon), Steyr of Austria produced the futuristic **AUG** and France the **FAMAS**. All of these were adopted for service, the Steyr achieving many export sales, but other designers stayed with the traditional layout.

Another generation of rifle designs began to emerge in the 1990s. Again, these showed a mixture of bullpup and traditional styles. Russia stayed with the traditional layout with the limited-production **AN-94**, as did Heckler & Koch with the **G36** range and their latest **HK416** and **HK417** rifles. FN backed both horses, continuing the development of traditional guns, culminating in the USSOCOM **SCAR** rifles in 5.56 mm and 7.62 mm, but also developed the **F2000** bullpup. Other bullpups also emerged, of which three significant models have so far made it into production: Singapore's STK **SAR-21**, Israel's **Tavor TAR-21/X95** and the Chinese 5.8mm **QBZ95** (also available in 5.56 mm as the QBZ97).

Clearly, there is a divergence of views over the relative merits of the traditional and bullpup layouts. This article is an attempt to assess their pros and cons, and consider whether all options have yet been explored.

Pros and cons

The traditional layout has the magazine and action ahead of the trigger and pistol grip. This is really a hang-over from the days of bolt action rifles, in which the bolt handle needed to be close to the trigger for rapid operation; this inevitably meant that the magazine and action were in front. In bullpup rifles the action and magazine are located behind the trigger, within the buttstock, thereby producing a much shorter weapon for the same barrel length as the traditional type.

The photo above shows the M16 (top) and the L85: despite its shorter overall length, the L85 has a slightly longer barrel

The advantages in reducing the length vary according to the design, as shown below.

Lengths are shown in centimetres first, with inches in brackets. The "carry length" is with the stock folded or telescoped (where possible). With either layout, the longer the barrel, the higher will be its percentage of the overall length (final column).

GUN	BARREL LENGTH	OVERALL LENGTH	CARRY LENGTH	BARREL AS % OF OVERALL
Traditional guns:				
M16 rifle	50.8 (20.0)	100.6 (39.6)	100.6 (39.6)	55.5 %
M4 carbine	36.8 (14.5)	84.0 (33.0)	76.0 (29.9)	43.8 %
HK G36	48.0 (18.9)	99.8 (39.3)	75.8 (29.8)	48.1 %
FN SCAR	45.7 (18.0)	99.1 (39.0)	73.7 (29.0)	46.1 %
FN SCAR	35.5 (14.0)	88.9 (35.0)	63.5 (25.0)	39.9 %
Bullpups:				
L85	51.8 (20.4)	78.5 (30.9)	78.5 (30.9)	66.0 %
Steyr AUG	50.8 (20.0)	80.5 (31.7)	80.5 (31.7)	63.1 %
Steyr AUG carbine	40.7 (16.0)	70.4 (27.7)	70.4 (27.7)	57.8 %
FAMAS	48.8 (19.2)	75.7 (29.8)	75.7 (29.8)	64.5 %
FN F2000	40.0 (15.7)	69.4 (27.3)	69.4 (27.3)	57.6 %
Tavor TAR-21	46.0 (18.1)	72.5 (28.5)	72.5 (28.5)	63.4 %
Tavor CTAR	38.0 (15.0)	64.0 (25.2)	64.0 (25.2)	59.4 %
QBZ95	46.3 (18.2)	74.3 (29.3)	74.3 (29.3)	62.3 %

The significant reduction in overall length that the bullpup provides is obvious, but various objections are often raised against this type of layout.

The case against the bullpup

1. In most bullpups, fired cartridge cases can only be ejected to the right-hand side of the gun, which means that they cannot be fired left-handed as the cases would hit the firer's face (most can be adapted for left-handers, but that takes time). This means that users can't switch shoulders to fire round the corner of a building, for instance.

2. Magazine changes are also argued by some to be more awkward, particularly when wearing body armour as the magazines are located so close to the body.

3. Drills to clear the weapons, including clearing jams, are said to be slower.

4. The necessarily straight-line stock means that the firer cannot sight along the top of the barrel, so if iron sights are used they have to stick up high above the barrel and the firer therefore has to expose more of his head 'above the parapet'.

5. Proponents of bayonet fighting will also point to the shorter length of the weapon, which means that you have to get closer to the enemy.

6. Those used to traditional rifles often claim that they feel better balanced with the weight forwards.

7. It is also frequently stated that bullpups have worse triggers than traditional guns, militating against accurate shooting.

8. Bullpups have the action by the firer's head, which some find uncomfortable if not dangerous, and short-barrelled versions have the muzzle quite close to the firer, which means that muzzle blast can be more of a problem.

9. Keeping the action well clear of the stock allows the stock to telescope in stages, in order to vary the length of pull (LoP) to suit different users or different circumstances (e.g. wearing bulky body armour).

10. Ergonomics of bullpups are often poor, with the safety, fire select and magazine eject controls not close to hand.

The case for the bullpup

There are of course counter-arguments:

1. The lack of ability to switch shoulders may in practice be very little used by ordinary soldiers as opposed to special forces. Most soldiers in combat have enough trouble hitting the target when firing from their usual shoulder, let alone from their 'wrong' side, so many armies train only in shooting from one shoulder. In any case, a simple solution has been adopted by both the SAR-21 and the modified QBZ95-1: the ejection port has a case deflector at the rear so shaped that ejected cases are thrown forwards as much as sideways, so they do not hit the left-handed shooter's face. The FN F2000 solves the problem in a more thorough way by adopting a forward ejection tube, which carries the spent cases to the front of the gun before they are expelled. Some have identified this as a potential source of problems, but user tests reported so far indicate that it is a robust and reliable system. There are other possible ways of achieving an ambidextrous design, mentioned later.

2. The magazine change is not necessarily more difficult (I have seen British and Chinese soldiers changing magazines very quickly; there can only be a fraction of a second difference), and some users prefer the 'inboard' location as it can make it easier to change magazines when travelling in and shooting from a vehicle, or from behind cover.

3. Drills to clear some weapons may be slower (for example the complex FN F2000, in which the rear of the chamber is not readily visible in poor light) but the question then becomes: how much slower, and how important is that compared with other issues?

4. Military rifles are increasingly being issued with optical sights, so the iron-sights objection is less important. In any case, military rifles of traditional layout also have high-mounted sights nowadays, because they generally have straight-line stocks, in which the top of the buttstock continues in a

straight line from the barrel, instead of being angled downwards as in most older rifles.

5. Bayonet fighting is now too irrelevant to modern combat situations for their length to matter.

6. Gun balance is, to a great extent, a matter of what you are used to. Bullpup users usually prefer the rearwards weight balance, arguing that it is easier to hold one-handed, or for extended periods, and makes the rifle quicker to change aim. What is undoubtedly true is that a bullpup is far more evenly balanced once an under-barrel grenade launcher, optical sights and other tactical kit (e.g. laser pointers and torches) start being added: a traditional rifle then becomes massively front-heavy and tiring to hold in the aim.

7. While the triggers of some bullpups may not be good, most are entirely acceptable for their military (as opposed to target-shooting) purpose. The author has spent time on a range firing several modern military rifles – both bullpup and traditional – in quick succession, and never noticed any difference in the trigger actions.

8. The firer's head can be shielded from the action by using a tough kevlar cheek-piece, as with the STK SAR-21, and there is unlikely to be any increase in muzzle blast (in fact, it could be reduced) if the bullpup layout is used to provide a longer barrel rather than a shorter gun.

9. Since soldiers in Western armies now fight with body armour as standard, the obvious answer is to design rifles with a shorter length of pull suited to this, with the option of add-on spacer butt plates if required.

10. Some bullpups do have poor ergonomics but others do not - recent designs such as the X95 variant of the Tavor, the Radon MSBS and the new SAR BMCR match the control system of the M16 (including a magazine release button above the trigger) and the QBZ95-1 is also very close to that. One difference from the M16 is that the X95, QBZ95-1 and Radon feature bolt release buttons at the bottom of the stock immediately behind the magazine well - just where the firer's thumb would hit on inserting a new magazine, which is highly convenient.

Some additional points to throw into the argument:

There is an increasing tendency to fit suppressors to rifles to reduce their muzzle blast and flash – the US Army has expressed a wish to see all future small arms with suppressors. Initially this was wanted to make the firers (particularly snipers) more difficult to locate, but an additional motivation now is the prevalence of hearing damage among soldiers exposed to constant gunfire in combat. With barrels of the same length, a bullpup with a typical suppressor will still be shorter than a traditional rifle without one. It will also be better balanced.

Bullpup proponents will also point out that the needs of urban combat, plus the increasing deployment of troops in cramped helicopters or armoured vehicles, put a

premium on compactness, as demonstrated by the fact that the US Army has largely switched over from the M16 rifle to the M4 carbine.

Traditional rifles can only match a bullpup's short length by using stocks which can be folded alongside the barrel, or sometimes over the top of it, or telescope entirely. Folded-stock rifles are as short as bullpups for carrying purposes, but take a couple of seconds for the stock to be unfolded before use (essential to obtain any kind of accuracy) which may be a handicap if, for example, the vehicle is immobilised in an ambush and the troops have to get out and start shooting instantly. Even more important, the stock needs to be in place during urban combat to stand any chance of hitting anything, so the rifle is at full length. There is actually little advantage in keeping the stock folded in combat, as the user's hands will still be in the same position (pistol grip, plus forward of the magazine) regardless of whether or not the stock is folded, so the barrel will protrude just as much. Furthermore, depending on their design folding stocks may be less rigid and comfortable to shoot with than fixed stocks. Finally, not all rifles are able to use folding stocks anyway because the action may extend into the stock (e.g. the M16 and M4, and the HK416/417). In such cases partly telescoping stocks may be used instead, but these do not deliver such a reduction in length as a folding stock, and cannot match the compactness of a bullpup.

The only other option to achieve a short length with a traditional layout is to reduce significantly the length of the barrel, to the detriment of ballistics and effectiveness, especially at longer ranges. This route has been followed by the US Army with the M4 carbine. Even so, with stock extended the M4 is 5.5 cm (2 inches) longer than an L85 while having a barrel which is 15 cm (6 inches) shorter.

The M4/M16 family is usually held up as the optimum in ergonomics, but it is interesting to note that the Israeli army has been changing over from them to the X95 for some years. According to informal reports, the changeover training is quick and easy and, once they've had the chance to assess both rifles, the majority of soldiers prefer the X95.

Alternative bullpups?

There are various types of bullpup layout which would help to get over the principal substantial objection to them: the problems of switching to firing left-handed. One solution is already in military service as the FN F2000 as noted above, with similar forward-eject systems also being used in the commercial 7.62x51 **Kel-Tec RFB** and the developmental multi-calibre **Desert Tech MDR** and **STK BMCR**. Another alternative is used by the multi-calibre **Kel-Tec RDB** and related **M43**, which use downward ejection behind the magazine: how well this works remains to be seen.

Four other possible alternatives have occurred to the author (there may be more).

Option 1 is to have the fired cases ejected straight upwards, in such a way that they strike the angled underside of a cheekpiece and are thereby deflected to one side, away from the firer. Switching sides would then be a matter of pivoting the cheekpiece over, which would take a couple of seconds. Putting a rubber pad on the

underside of the cheekpiece would cushion the shock and encourage the cases to bounce well away from the gun. The cheekpiece would also provide protection against a breech explosion. The principal concern with this approach would be to ensure that there was no risk of the fired case bouncing back into the action and causing a stoppage.

Option 2 is a variation on this: have an upward-ejecting arrangement as Option 1, but have the magazine angled away from the vertical so that, for right-handed shooting, the magazine is angled to the left and the gun ejects to the right. The tricky bit of the design would be to make it possible to rotate the magazine (and therefore the ejection) to the opposite side. This has been done in at least one experimental weapon, however: the Colt IMP bullpup PDW of the 1960s, in which the magazine and pistol grip could be rotated +/- 38 degrees out of line. This inspired the development of the Bushmaster ARM gun shown below. Having the magazine angled away from the vertical would cause a minor imbalance, but should make magazine changes easier, especially while lying prone.

Option 3 could be to turn the action upside down so that ejection is downwards. The top-mounted magazine would be a drum rather than a box type in order to avoid obscuring the sights and to do double duty as a cheekpiece so that the firer could switch shoulders without needing to make any adjustments. The gravity-aided feed and ejection processes should be more reliable than a conventional gun's.

Option 4 has been suggested by the development of the new Beretta ARX-160, which uses a traditional layout but has twin ejection ports with switchable ejection: just flicking a switch changes which side the gun ejects. This would seem to be an extravagant luxury for a traditional gun, but a very useful feature for a bullpup. It could be combined with the idea of the pivoting cheekpiece in Option 1, so that switching the cheekpiece over automatically changes the direction of ejection (perhaps just by moving the extractor/ejector). As with Option 1, the cheekpiece would also shield the firer's face from any gases escaping from the unused ejection port, as well as providing some protection if made strong enough to resist a chamber explosion (as with the SAR-21). Finally, the position of the cheekpiece would provide an obvious visual check on which side the gun was set to eject.

Whether the FN F2000 solution is adopted, or something different like those suggested above (my favourite being Option 4), it is clear that fully ambidextrous bullpups can be provided.

This leaves one practical disadvantage of the bullpup: the fact that in current models the stock cannot be adjusted for length (except for the VHS-2 – but by all accounts that provides a choice between long or very long LoP!). As already mentioned, it could be argued that it isn't necessary because new designs (whether bullpup or traditional) ought to feature a shorter LoP to allow for body armour anyway. However, it is clear that the US Army has decided that a variable LoP is a worthwhile feature, so a bullpup should ideally offer this. It would of course be possible to design a bullpup with the action mounted about 75 mm forward to provide room for a telescoping element in the butt, but this would increase the overall length of the gun as well as possibly bringing the pistol grip and butt uncomfortably close together, unless the action were designed to minimise the length behind the magazine.

Up to now there has been no pressure to reduce the length of the action, but there are various technical options which can be used. The most extreme case is demonstrated by the experimental Russian Korobov TKB-022 of the early 1960s shown below *(with acknowledgements to Max Popenker)*, but it wouldn't be necessary to adopt such a drastic solution.

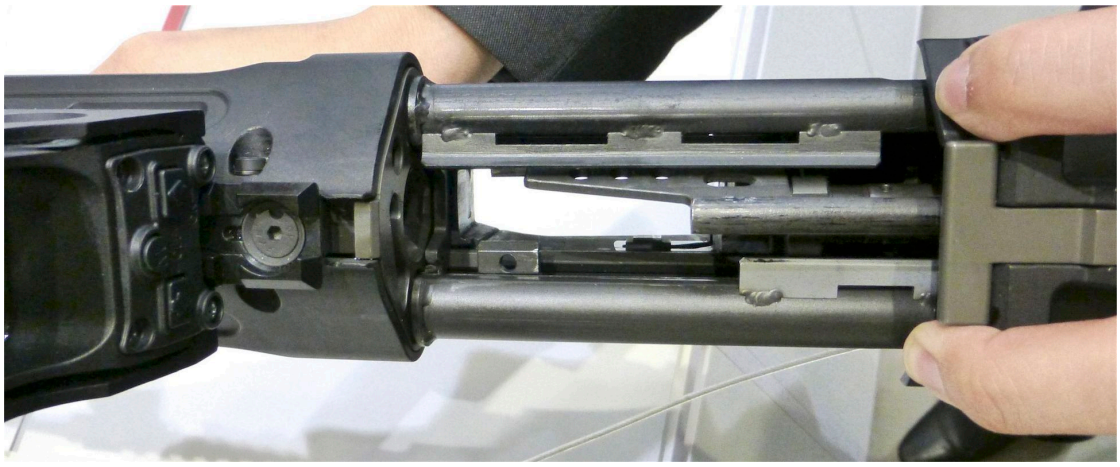
Another approach would be to provide a pistol grip and trigger unit which can slide to some degree along the length of the gun, effectively altering the length of pull. This could potentially face the same problem of bringing the magazine and the pistol grip too close, although a shorter behind-magazine action, or the ambidextrous solutions in Options 2 and 3 above, would resolve this. The main remaining problem would be to ensure a reliable, good-quality connection with the sear. This would be straightforward if an electrical trigger system were adopted (as was done in experiments with a modified SA80); while the thought of this would give many experienced soldiers palpitations, electrical systems are becoming increasingly essential to modern soldiers and will become even more so in the future. In any case, a sliding grip could be managed even with a conventional trigger. In a bullpup, a transfer bar is required to transmit the trigger movement to the sear in the stock. To design a bar with a series of holes, to provide alternative connecting points for the trigger mechanism, should not cause undue difficulties.

One possible issue is the desirability of a long, soft recoil stroke in reducing both the rate of fire and perceived recoil (as achieved by the STK Ultimax 100 SAW), especially with more powerful cartridges. This might be achieved even with a short action if the gas piston were geared to the bolt, so that a long movement of the piston resulted in a short movement of the bolt. If the piston and bolt were permanently mechanically linked, the recoil return spring could operate on the piston rather than the bolt, eliminating the need for space behind the bolt to house the spring. This would also have the advantage of making the extraction and chambering phases less violent and therefore potentially more reliable.

New military bullpups

The three latest bullpup rifles intended for military use are the **STK BMCR** (Bullpup Multirole Combat Rifle), the Polish Radon **MSBS** (Modułowy System Broni Strzeleckiej = Modular Firearm System) and the Croatian **VHS-2**. The STK (which is still at an early stage of development) is also available repackaged in a traditional format as the CMCR (Conventional Multirole Combat Rifle), while the Radon goes one better: the modularity extends as far as being able to assemble a bullpup or a traditional rifle from the same kit of parts, with 80% commonality between them (the main difference being in the stock).

The **BMCR** (shown below) has been designed using all of STK's experience with the SAR-21 rifle and features various improvements. The most interesting one is a forward ejection system via a short trough in the receiver (shown in the second photo), making the rifle fully ambidextrous without the complexity seen in the FN F2000, for instance; the breech is very easy to check.



The **Radon** (shown below) is further along in its development, with an initial batch of 200 rifles having been ordered. It is apparently intended to permit each branch of the armed forces to select which format they prefer, providing a unique opportunity to assess the relative merits of the formats within the same armed forces. The controls are ambidextrous and, like the Tavor, the action is convertible between right and left-side ejection and reportedly also ejects the cases as much forwards as sideways, permitting wrong-hand firing in an emergency. Having said that, it does not address all of the issues since the bullpup stock is not adjustable for length. This is the most interesting new small arms project in Europe, and is well worth careful examination by anyone concerned with the development of new military rifles.

The view above of the Radon MSBS shows the conventional controls, with the three-position fire selector just above and behind the trigger and the magazine eject button just above the forward end of the trigger guard. There is a button flush with the bottom of the receiver just behind the magazine well; this pops out when the bolt is held back on emptying the magazine, and releases the bolt when pressed upwards.

The **VHS-2** is fully ambidextrous, combining a quickly-switchable ejection side with a big case deflector for emergency left-handed shooting. Uniquely for a bullpup, it has an adjustable stock length, but as mentioned this appears to be of little use. The earlier VHS has been in service for some years, and the newer model will be replacing it. The gun reportedly performed well in the recent tests for the AIF – the new French infantry rifle – although not well enough to be chosen.

The VHS-2: the configuration and appearance do vary depending on the model

Conclusions

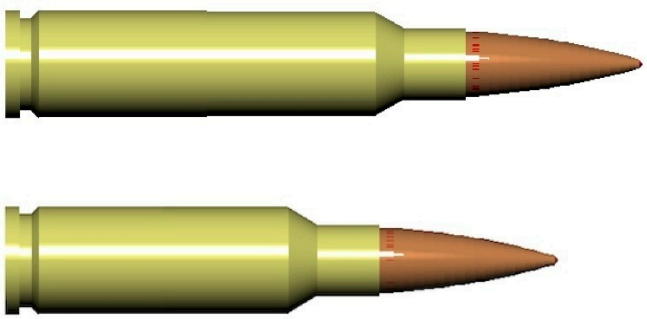
To sum up, all weapon designs have their own pros and cons which need to be weighed up against each other to determine the best overall compromise. The major advantage of a bullpup - a saving of around 20 cm (8 inches) in overall length for the same length barrel - is very significant in modern combat, in which troops may be fighting at short range in a village at one moment (requiring a compact gun) then need to respond to long-range fire as they leave (requiring a long barrel).

It is interesting to note that in adopting the IWI X95 member of the Tavor 5.56 mm family, the Israelis have not taken advantage of length saving to provide a long barrel; they evidently regard keeping the fromt of the gun as short as possible as a key advantage, presumably for urban fighting.

The other major bullpup advantage is the much superior weight balance when suppressors, UGLs and other increasingly common accessories are added to the gun. With an optimised design of the type I have suggested above, there need no longer be any serious practical objections to the bullpup layout: those raised by supporters of traditional rifles can either be addressed, or on examination are not significant and usually boil down to personal preference.

Some final thoughts: the current interest in the possibility of a new general-purpose long-range cartridge to replace both the 5.56 x 45 and the 7.62 x 51 enhances the case for the bullpup solution. It could be argued that a 7.62 mm rifle, being intended primarily for long-range fire, need not be compact, while a 5.56 mm carbine, being optimised for relatively short ranges, is not greatly disadvantaged by a short barrel. However, a general-purpose rifle in a general-purpose calibre would need to be short for urban fighting but have a long barrel for optimum long-range ballistics. This can only be achieved in one gun by using the bullpup layout, unless soldiers are to be expected to carry two barrels of different lengths and keep swapping them as the range changes; or if the designers have produced a cartridge powerful enough to provide good ballistics from a short barrel, in which case there are penalties (see below).

The design of a new general-purpose cartridge could be influenced by which layout is chosen, if the bullpup's compactness is used to provide a longer barrel rather than a shorter gun. This is because there is an inverse relationship between the barrel length and the size and power of the cartridge required to achieve any given ballistics: other things being equal, the shorter the barrel, the more powerful the cartridge needs to be. This is illustrated by the two notional 6.5mm cartridges shown below (courtesy of Joe Smith). Both of them are designed to develop a muzzle energy of 2,500 J (1,850 ft lbs): the shorter cartridge (basically the 6.5mm Grendel) will achieve this from a 24" (c. 600 mm) barrel; the larger cartridge (around 9 mm longer and similar to the USAMU 264 USA), is required to accommodate enough propellant to achieve the same muzzle energy from a 16 inch (c. 400 mm) barrel.



To put it another way, there is a choice between two rifles of the same overall length and ballistic performance: a bullpup using the short cartridge, or a traditional carbine using the long cartridge. The bullpup solution allows the selection of lighter ammunition, developing less recoil, and with a much smaller firing signature in terms of muzzle flash and blast, thereby needing a significantly smaller and lighter suppressor to achieve any given decibel level.

CTSAS

The US Army is currently sponsoring the development of a Cased Telescoped Small Arms System (CTSAS), formerly known as the Lightweight Small Arms Technologies project (LSAT), with Textron as the lead contractor. The polymer cartridge is cylindrical and the guns (MG and carbine) both use mechanisms which feature separate, movable chambers with push-through ejection. Such ammunition is incompatible with conventional gun actions (nothing for an extractor to hook onto), so if CTSAS succeeds in being adopted, all military gun makers who want to compete for business will have to design new weapons.

One maker who already has a starting point for such a design is Steyr Mannlicher, who in the 1980s developed the **Steyr ACR**, a competitor in the US Advanced Combat Rifle trials. This fired flechettes, but used cylindrical polymer cased-telescoped ammunition with a separate movable chamber and push-through ejection. The main change would be from a ring-primer to a base-primer, which would require a new firing mechanism. However, there would be plenty of scope to add one as the gun action was exceptionally short; here are comparisons with two contemporary rifles; Steyr's own AUG bullpup and the conventional M16A2:

1. Steyr AUG overall length 805 mm, barrel length 508 mm. Difference 297 mm.
2. Steyr ACR overall length 765 mm, barrel length 540 mm. Difference 225 mm.
3. M16A2 overall length 1006 mm, barrel length 508 mm. Difference 498 mm.

So the AUG saved 201 mm in overall length over the M16 (almost 8 inches) while the ACR saved 273 mm (10.75 inches).

Steyr ACR

There would therefore be scope to allow some more space at the back of the gun for a collapsible stock, compensated by relocating the pistol grip a little further back. There would still be a very substantial length saving compared with a traditional gun.

Further details plus illustrations of the guns mentioned in this article can be found on Maxim Popenker's site: http://modernfirearms.net/assault/book-e.htm