Small Arms Ammunition for the 21st Century:

High-Performance Alternatives to the 5.56 NATO Round

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Editor's Note: *While we are not recommending replacement of the 5.56x45mm round, discussion of current service and developmental rounds and their characteristics can be useful. Revised and updated from the July-August 2004 issue of* Infantry.

It has been four decades since the 7.62mm NATO round was first superseded as the ammunition of choice for U.S. combat rifles when the 5.56x45mm M193 cartridge — and the M16A1 rifle that fired it — proved better suited to the battlefields of Vietnam. When 5.56x45mm ammunition became NATO-standard about 20 years ago, projectile weight was boosted from 55 grains to 62 grains, and the heavier, "green-tip" round was type-classified as M855 Ball in U.S. service.

Accounts from the Vietnam War indicate that M193 ammo was very lethal at the relatively short engagement distances encountered in jungle warfare, and could penetrate the walls of typical bamboo huts with ease. However, circumstances were much different when, many years later, Soldiers were again sent into harm's way in the hostile regions of Somalia, Afghanistan, and Iraq.

In Somalia it became all too apparent that the M855 round was lacking in the ability to punch through the brick walls and other obstacles commonly encountered in urban areas. As Captain John Hodge related in his article, "The M240B Machine Gun" (*Infantry*, March-June 1997, p. 8), it was noted that "…while the M249 provided good firepower, in some situations, they needed greater range and penetration power." Equally disturbing were the reports that when M855 ammo was fired from the M4 carbines employed by special operations personnel, it too often required multiple hits to neutralize an opponent, even though many Somali males were of slight build.

These problems were soon magnified as more individuals were armed with the short-barreled, M4-series weapons. Soldiers of the 82nd Airborne and 101st Air Assault Divisions had their M16A2 rifles replaced by M4 and M4A1 carbines in the years prior to conducting combat operations in Afghanistan and Iraq. Also, in these units and others, like the Stryker brigades, the standard M249 light machine gun (LMG) is being considered for replacement by a paratrooper model with a barrel as short as that of the M4 carbine.

While these alterations do result in a weapon that is lighter and easier to handle in the confined interior spaces of infantry vehicles, utility helicopters and urban buildings, terminal performance suffers. The primary mechanism behind the lethality of 5.56mm ammo is the fragmentation that results when the bullet impacts soft tissue at high speed. The truncated barrels do not create sufficient velocity to produce this effect beyond a short distance, nor do they provide sufficient "reach" to engage enemy personnel at the extended ranges encountered in desert and mountain warfare.

Given the trend to acquire lightweight small arms with abbreviated barrels, combined with the decreased performance of the M855 Ball round out of a short barrel, what can be done to regain the lost capabilities?

Option 1: Create a 5.56mm "heavy ball" load

The simplest approach to improving the combat potential of 5.56mm weapons is to increase bullet weight. This has been done on a limited scale by special operations forces, which have used Mk262 competition ammo in the mountains of Afghanistan. The 77-grain "open tip" match bullet reportedly is effective when used against unprotected enemy personnel, but the open tip design is less capable than a full metal jacket (FMJ) projectile for penetration of barricades, brick walls, vehicles and other "hard" targets.

In the 1960s a German company developed a "heavy ball" load with a steel-jacketed, 77-grain bullet that would be a viable quick-fix to the problem, since long range trajectory and hard target penetration appear to be better than that of the M855 round. The manufacturer was unable to generate any interest at the time, no doubt because the heavy projectile was incompatible with the slow rifling twist used in M16A1 barrels. However, since it would be stabilized by the faster twist that is used in the M16A2 and M249, it could be worthwhile to either resurrect this loading, or create a FMJ version of the 77-grain Mk262 ammo.

Although it performs well in some circumstances, the 5.56x45mm cartridge has been found wanting in others, and lacks the growth potential necessary to meet these demands. While a heavier bullet would certainly boost the performance of 5.56mm NATO, if a substantial improvement is desired it

Figure 1 — Low cost options for improving performance over the 5.56x45mm round (left), are the 6x45mm (center), and 6.5x42mm MPC (right). These cartridges are compatible with 5.56mm magazines and bolts, M27 metallic links, and the M249 feed mechanism.

Figure 2 — Threat small arms ammunition: (l. to r.) Russian 5.45x39mm, Chinese 5.8x42mm, Russian/Chinese 7.62x39mm. The 5.8x42mm is the best combat rifle/LMG round currently in service, and has more "growth potential" than other intermediate cartridges.

Figure 3 —5.56mm projectiles: (l. to r.) 55-grain M193 Ball, 62-grain M855 Ball, 77-grain "heavy ball." The steel jacket of the heavy ball bullet is tougher than the gilding metal jackets of the other two, enabling better penetration of typical battlefield obstacles.

may be necessary to adopt an entirely new caliber. It would be best if any new cartridge were dimensioned so that current and future weapons can be reconfigured to fire it at minimal cost. This limits cartridge overall length to that of the 5.56x45mm round, but allows some flexibility in regards to case diameter.

Option 2: Load a bigger bullet in the 5.56x45mm case

The second easiest way to increase performance is to "neck up" the 5.56x45mm case to accept a 6mm bullet, something that has been done by civilian competition and varmint shooters who wanted more capability than the original round could provide. The result is the "wildcat" 6x45mm cartridge (not to be confused with the 6x45mm XM732 round that was developed in the 1970s), which can be loaded with a 90-grain FMJ bullet to an overall length the same as that of 5.56x45mm. The 6x45mm promises increased range and lethality compared to the M855 round, yet requires little more than a barrel change to be fired in existing 5.56mm weapons.

In order to wrest the greatest possible performance from a cartridge case of such small diameter, it may be necessary to increase bullet diameter even more. This approach was taken in 2004, when a noted civilian gunsmith started work on another "drop-in" solution to the stopping power problem reported with short-barreled 5.56mm weapons. The neck of the 5.56mm NATO case was increased sufficiently to accept a 6.5mm bullet, while case length was shortened slightly to 42mm, just enough to accept projectiles of higher ballistic efficiency than the original length would allow. The result was the 6.5x42mm Multi Purpose Cartridge (MPC), which produces impact energies that are 30-50 percent greater than M855 Ball at normal engagement distances (up to 300 meters). Like the 6x45mm round, the 6.5x42mm cartridge fits in, and feeds from, magazines and metallic links made for 5.56mm NATO ammunition, but delivers greater terminal performance.

Option 3: Use a bigger bullet and a bigger cartridge case

The perceived incapacitation failures of the M855 round during operations in Afghanistan triggered an effort by a few innovative Soldiers to create a more potent cartridge for the M4 carbine. With the approval of their commander, these individuals, with assistance from a major ammunition company, developed the 6.8x43mm Special Purpose Cartridge (SPC). The 6.8mm SPC hits much harder than 5.56mm Ball at all engagement distances, but because the 115-grain bullet has rather modest aerodynamic qualities, trajectory and wind drift show little or no improvement.

The 6.8mm SPC is quite adequate for engagements of point targets to a distance of about 500 meters, but for shots at longer range, greater ballistic efficiency is called for. To achieve this, a competition shooter and a firearms maker collaborated on a cartridge that could give the M16 the capability for precision shots out to 1000 meters, or more. The result was christened the 6.5mm Grendel (it was named after a fabled mythological monster), and this 6.5x38mm round is capable of shooting highly-streamlined bullets with a flatter trajectory and less wind drift than even 7.62mm M80 Ball ammo.

Conversion of 5.56mm rifles and carbines to 6.8mm SPC or 6.5mm Grendel is rather an expensive procedure, requiring not only a change of barrels and bolts, but also replacement of magazines, along with development of caliber-specific stripper clips. Additionally, converting 5.56mm LMGs to either caliber will be considerably more difficult and costly, necessitating the redesign of the belt feed mechanism, together with development of a new series of metallic links.

The Soldier's Load

In addition to cost and complexity of conversion, a major drawback of both the 6.8mm SPC and 6.5mm Grendel is the weight of the ammunition, which is more than 40 percent heavier than that of the 5.56mm NATO cartridge. Also, the 25-round magazines made for the two larger rounds are constructed of steel, so they

5.56x45 — 10 x 30-round magazines = 300 rounds

6x45 & 6.5x42 — 9 x 30-round magazines = 270 rounds

6.5x38 & 6.8x43 — 8 x 25-round magazines = 200 rounds

are heavier than the standard issue aluminum magazines that can be used with the smaller cartridges. Therefore, the number of loaded magazines that can be carried for a given weight differs significantly between the two sets of alternatives. If the rifleman's basic load of ammo is kept at a constant weight, the box above shows how the number of rounds varies per caliber.

This difference can be critical in sustained combat where resupply is not possible, and can be a major factor determining victory or defeat, survival or death. As an example, a veteran of early battles in Vietnam attributed the successful outcome of those actions to the increased amount of 5.56mm ammo that the infantrymen could carry, and is certain that his unit would have been overrun had they been armed with 7.62mm rifles. However, the quantity of ammunition that can be carried must be balanced against terminal effects, penetration capability, weapon controllability, and other factors.

Ballistics Tables

Ballistics tables are useful tools when comparing different cartridges, but in this particular instance, the data contained therein must be evaluated with a bit of caution. This is due to a number of factors, most important of which is that the load development of the candidate rounds is ongoing, with different FMJ bullet designs being created and tested in an effort to achieve optimum combat capability and terminal performance.

Figure 5 — Magazines for the 5.56mm NATO cartridge (left) can be used with the 6.5mm MPC (right), and the 6x45mm round (not shown). Also, 6.5mm MPC and 6x45mm cartridges fit perfectly into 5.56mm stripper clips. For 6.5mm Grendel and 6.8mm SPC, it would be necessary to manufacture new magazines, stripper clips, and clip guides.

Figure 6 — The 6x45mm (not shown) and the 6.5mm MPC, seen here plugged into standard M27 links and positioned on an M249 feed tray, essentially require only a barrel change for conversion of the LMG. However, the 6.8mm SPC and 6.5mm Grendel, need a new series of links designed and manufactured, and the M249 feed mechanism modified.

As of this writing, the 6x45mm and 6.5mm MPC are made solely by and for handloaders, with no commercial off-the-shelf (COTS) FMJ ammunition being available. A 90-grain FMJ bullet is available for the 6x45mm, and use of that projectile is assumed in the accompanying tables. Because there is no COTS 95-grain FMJ bullet for use in the 6.5mm MPC, data for a hunting-type projectile was substituted.

There are two COTS versions of the 6.8mm SPC with a 115-grain FMJ bullet. The manufacturer calls one a "commercial" round, and the other a "combat" load. Since the latter is a high-pressure load that may not be safe in some weapons, the commercial version was selected for inclusion in the tables.

Pre-production 6.5mm Grendel ammunition loaded with a 110-grain FMJ bullet is currently being tested. Specifications are preliminary and subject to revision, but they are used herein because at present there are no other FMJ factory loads in this caliber.

Velocity and energy tables can help the reader in forming an opinion as to which, if any, of these rounds are worthy of further development. Once that decision is reached, better FMJ projectiles can be designed for optimum terminal effectiveness in soft tissue, and penetration of "hard" targets.

Summary

Which is the best cartridge for upgrading the combat capability of 5.56mm infantry weapons depends on just how much improvement is desired. Clearly, a 5.56mm heavy bullet load would be the most economical choice, because no alterations to the weapons are necessary, although expected performance increase is minimal. Opting for the 6x45mm or

6.5mm MPC would provide more significant gains, yet require little more than a barrel change, since these rounds fit existing bolts, magazines, and metallic links.

The 6.8x43mm and 6.5x38mm are the most capable upgrades, but they are also the most expensive. The 6.8mm SPC would provide a substantial improvement in close combat capability, which was its stated design purpose. However, the streamlined projectiles fired by the 6.5mm Grendel deliver vastly superior all-around performance, combining improved terminal effects with greatly enhanced capability to "reach out and touch someone" at long distance.

When it was learned in the early 1990s that the Chinese army was planning to field a new family of small arms, it was widely thought that the new weapons would be chambered for the Russian 5.45x39mm cartridge. To the surprise of experts worldwide, the Chinese instead created a unique 5.8x42mm round that, by any objective standards, must be considered the best assault rifle cartridge currently in service. The U.S. Army should take similarly bold action and adopt a new, more capable rifle cartridge so that Soldiers will be better armed to meet the challenges that they will encounter on the diverse battlefields of the 21st century.

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Velocity (ft/sec) – 20.0" barrel		Range (yards)						Deflection@1000yds
Cartridge	**Bullet**	**0**	**100**	**300**	**500**	**800**	**1000**	**10 mi/hr crosswind**
5.56x45mm	62gr	3100	2762	2156	1638	1107	947	79 in
5.56x45mm	77gr	2720	2483	2047	1660	1215	1040	64 in
6x45mm	90gr	2650	2417	1989	1612	1185	1024	66 in
6.5x42mm	95gr	2700	2229	2013	1622	1182	1018	67 in
6.8x43mm	115gr	2575	2311	1834	1433	1051	930	80 in
6.5x38mm	110gr	2670	2478	2119	1793	1380	1176	50 in

Energy (ft-lbs) – 20.0" barrel		Range (yards)						Maximum Trajectory
Cartridge	**Bullet**	**0**	**100**	**300**	**500**	**800**	**1000**	**when fired to 1000yds**
5.56x45mm	62gr	1323	1050	640	369	169	124	193 in
5.56x45mm	77gr	1265	1054	716	471	252	185	176 in
6x45mm	90gr	1403	1167	791	519	281	210	186 in
6.5x42mm	95gr	1538	1274	855	555	295	219	185 in
6.8x43mm	115gr	1693	1364	859	524	282	221	235 in
6.5x38mm	110gr	1741	1499	1096	785	465	338	146 in

Velocity (ft/sec) – 14.5" barrel		Range (yards)						Deflection @ 1000yds
Cartridge	**Bullet**	**0**	**100**	**300**	**500**	**800**	**1000**	**10 mi/hr crosswind**
5.56x45mm	62gr	2860	2539	1964	1482	1038	908	86 in
5.56x45mm	77gr	2500	2275	1862	1503	1122	987	70 in
6x45mm	90gr	2550	2322	1905	1540	1143	1000	68 in
6.5x42mm	95gr	2600	2363	1929	1550	1140	995	69 in
6.8x43mm	115gr	2500	2241	1773	1384	1030	917	82 in
6.5x38mm	110gr	2485	2301	1958	1648	1273	1104	55 in

Energy (ft-lbs) – 14.5" barrel		Range (yards)						Maximum Trajectory
Cartridge	**Bullet**	**0**	**100**	**300**	**500**	**800**	**1000**	**when fired to 1000yds**
5.56x45mm	62gr	1126	887	531	302	148	114	228 in
5.56x45mm	77gr	1068	884	592	386	215	167	211 in
6x45mm	90gr	1299	1078	725	474	261	200	202 in
6.5x42mm	95gr	1426	1178	785	507	274	209	201in
6.8x43mm	115gr	1596	1282	803	489	271	215	249 in
6.5x38mm	110gr	1508	1293	936	664	396	297	172 in