Gary K. Roberts, D.D.S.
750 Welch Road, Suite 118
Palo Alto, CA 94304

31 March 2013

Thank you for the opportunity to address some relevant factors effecting LE wound ballistics. Hopefully you will find this helpful for your agency. I also strongly recommend contacting SSA Scott Patterson (703-632-1802/a.patterson@ic.fbi.gov) at the FBI BRF in Quantico, VA for a copy of their data.

WOUND BALLISTIC TERMINAL PERFORMANCE FACTS

The last 25 years of modern wound ballistic research has demonstrated yet again what historical reports have always indicated--that there are only two valid methods of incapacitation: one based on psychological factors and the other physiological damage. People are often rapidly psychologically incapacitated by minor wounds that are not immediately physiologically incapacitating. Psychological factors are also the reason people can receive severe, even non-survivable wounds and continue functioning for short periods of time. Up to fifty percent of those individuals rapidly incapacitated by bullet wounds are probably incapacitated for psychological rather than physiological reasons. Psychological incapacitation is an extremely erratic, highly variable, and completely unpredictable human response, independent of any inherent characteristics of a particular projectile.

The degree and rapidity of any physiological incapacitation is determined by the anatomic structures the projectile disrupts and the severity the tissue damage caused by the bullet. Physiologically, immediate incapacitation or death can only occur when the brain or upper spinal cord is damaged or destroyed. The tactical reality is that in shooting incidents, opportunities for law enforcement (LE) personnel to take precisely aimed shots at the CNS of threatening opponents is rare due to high stress unexpected contact marked by rapid fleeting movements, along with frequent poor visibility of the target caused by darkness, innocent bystanders, and the use of cover and concealment. Battlefield conditions for military personnel can be even more chaotic. Thus the reduced likelihood of frequent planned CNS targeting in lethal force encounters. Absent CNS damage, circulatory system collapse from severe disruption of the vital organs and blood vessels in the torso is the only other reliable method of physiological incapacitation from small arms. If the CNS is uninjured, physiological incapacitation is delayed until blood loss is sufficient to deprive the brain of oxygen. Multiple hits may be needed before an individual is physiologically incapacitated. An individual wounded in any area of the body other than the CNS may physiologically be able to continue their actions for a short period of time, even with non-survivable injuries. In a 1992 IWBA Journal paper, Dr. Ken Newgard wrote the following about how blood loss effects incapacitation:

"A 70 kg male has a cardiac output of around 5.5 liters per minute. His blood volume is about 4200 cc. Assuming that his cardiac output can double under stress, his aortic blood flow can reach 11 Liters per minute. If this male had his thoracic aorta totally severed, it would take him 4.6 seconds to lose 20% of his total blood volume. This is the minimum amount of time in which a person could lose 20% of his blood volume from one point of injury. A marginally trained person can fire at a rate of two shots per second. In 4.6 seconds there could easily be 9 shots of return fire before the assailant's activity is neutralized. Note this analysis does not account for oxygen contained in the blood already perusing the brain that will keep the brain functioning for an even longer period of time."

LE personnel are generally trained to shoot at the center of mass, usually the torso, of an aggressive opponent who must be stopped through the use of lethal force. Physiological incapacitation with wounds to the torso is usually the result of circulatory system collapse. More rapid incapacitation may occur with greater tissue disruption. Tissue is damaged through two wounding mechanisms: the tissue in the projectile's path is permanently crushed and the tissue surrounding the projectile's path is temporarily stretched. A penetrating projectile physically crushes and destroys tissue as it cuts its path through the body. The space occupied by this pulped and disintegrated tissue is referred to as the permanent cavity. The permanent cavity, or wound track, is quite simply the hole bored by the projectile's passage. Obviously, bullets of greater diameter crush more tissue, forming a larger permanent cavity. The formation of this permanent cavity is consistent and reliable.

The tissue surrounding the permanent cavity is briefly pushed laterally aside as it is centrifugally driven radially outward by the projectile's passage. The empty space normally occupied by the momentarily displaced tissue surrounding the wound track is called the temporary cavity. The temporary cavity quickly subsides as the elastic recoil of the stretched tissue returns it towards the wound track. The tissue that was stretched by the temporary cavity may be injured and is analogous to an area of blunt trauma surrounding the permanent crush cavity. The degree of injury produced by temporary cavitation is quite variable, erratic, and highly dependent on anatomic and physiologic considerations. Many flexible, elastic soft tissues such as muscle, bowel wall, skin, blood vessels, and empty hollow organs (*stomach, intestines, bladder, etc…*) are good energy absorbers and are highly resistant to the blunt trauma and contusion caused by the stretch of temporary cavitation. Inelastic tissues such as the liver, kidney, spleen, pancreas, brain, and completely full fluid or gas filled hollow organs are highly susceptible to severe permanent splitting, tearing, and rupture due to temporary cavitation insults. Projectiles are traveling at their maximum velocity when they initially strike and then slow as they travel through tissue. In spite of this, the maximum temporary cavity is not always found at the surface where the projectile is at its highest velocity, but often deeper in the tissue after it has slowed considerably. The maximum temporary cavitation is usually coincidental with that of maximum bullet yaw, deformation, or fragmentation, but not necessarily maximum projectile velocity.

All projectiles that penetrate the body can only disrupt tissue by these two wounding mechanisms: the localized crushing of tissue in the bullet's path and the transient stretching of tissue adjacent to the wound track. Projectile wounds differ in the amount and location of crushed and stretched tissue. The relative contribution by each of these mechanisms to any wound depends on the physical characteristics of the projectile, its size, weight, shape, construction, and velocity, penetration depth and the type of tissue with which the projectile interacts. Unlike rifle bullets, handgun bullets,

regardless of whether they are fired from pistols or SMG's, generally only disrupt tissue by the crush mechanism. In addition, temporary cavitation from most handgun bullets does not reliably damage tissue and is not usually a significant mechanism of wounding.

Bullets that may be required to incapacitate aggressors must reliably penetrate a minimum of approximately 10 to 12 inches of tissue in order to ensure disruption of the major organs and blood vessels in the torso from any angle and through excessive adipose tissue, hypertrophied muscle, or intervening anatomic structures, such as a raised arm.

Tissue is a denser medium than air; as the bullets strikes tissue, the increased drag on the projectile overcomes its rotational stabilization and the bullet can yaw. If the bullet yaws, more surface area is in contact with tissue, so it crushes more tissue, creating a larger permanent cavity. When a bullet yaws, it also displaces more of the surrounding tissue, increasing the temporary cavity size. Both the largest permanent and temporary cavities are produced when the bullet is traveling sideways at 90 degrees of yaw, allowing the maximum lateral cross sectional area of the bullet to strike tissue and displace the greatest amount of tissue. Longer and wider bullets have a greater lateral cross sectional area and thus create a larger permanent cavity when they yaw.

Aerodynamic projectiles, such as bullets, cause minimal tissue disturbance when passing point forward through tissue. Deformation destroys the aerodynamic shape of the bullet, shortening its length and increasing its diameter by expanding and flattening the bullet tip in the classic "mushroom" pattern exhibited by deforming jacketed hollow point and jacketed soft point bullets. The larger frontal area of deformed bullets can crush more tissue, thus increasing permanent cavity size; more tissue is also displaced by a bullet with increased frontal area, causing an enlarged temporary cavity.

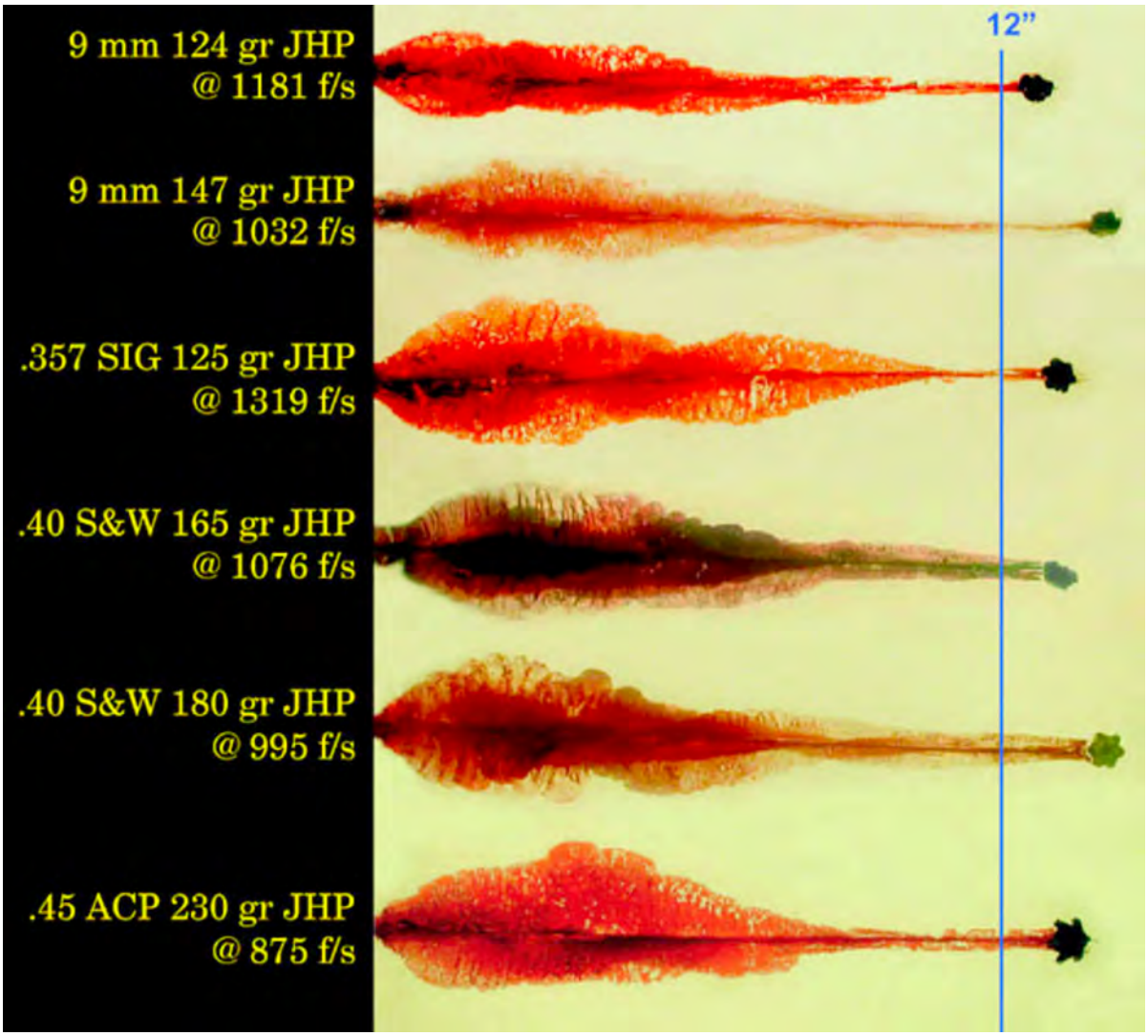
Projectile fragmentation in tissue can also greatly increase the permanent cavity size. When a bullet fragments in tissue, each of the multiple fragments spreads out radially from the main wound track, cutting its own path through tissue. This fragmentation acts synergistically with the stretch of temporary cavitation. The multiply perforated tissue loses its elasticity and is unable to absorb stretching that would ordinarily be tolerated by intact tissue. The temporary cavitation displacement of tissue, which occurs following the passage of the projectile, stretches this weakened tissue and can grossly disrupt its integrity, tearing and detaching pieces of tissue. Note that handgun bullets, regardless of whether they are fired from pistols or SMG's, do not generally exhibit the fragmentation effects produced by rifle bullets. If handgun bullets do fragment, the bullet fragments are usually found within 1 cm of the permanent cavity; wound severity is usually decreased by the fragmentation since the bullet mass is reduced, causing a smaller permanent crush cavity.

(*The Hague Declaration of 1899 prohibits the use of bullets that expand or flatten easily in the human body against combatants in international armed conflict; this does NOT prohibit the military use of bullets that fragment (hyper-expansion) or yaw upon entry into tissue. It is ludicrous to conclude that incapacitating dangerous opponents in combat while using the same deforming bullets legally relied on daily by LE agencies is somehow inhumane, while wounding or killing the same enemy using much more powerful destructive ordnance such as grenades, mines, mortars, artillery, rockets, bombs, CBU's, FAE's, and thermobarics is approved. This is not logical and does nothing to limit battlefield casualties. It is clearly time to re-evaluate the archaic 1899 Hague Convention. The Hague Convention's outmoded guidelines are no longer relevant for today's urban battlefield with its close intermixing of innocent civilians and irregular combatants. The use routine combat use of standard LE deforming ammunition is actually more humane as it can result in more rapid incapacitation, with less shots fired.)*

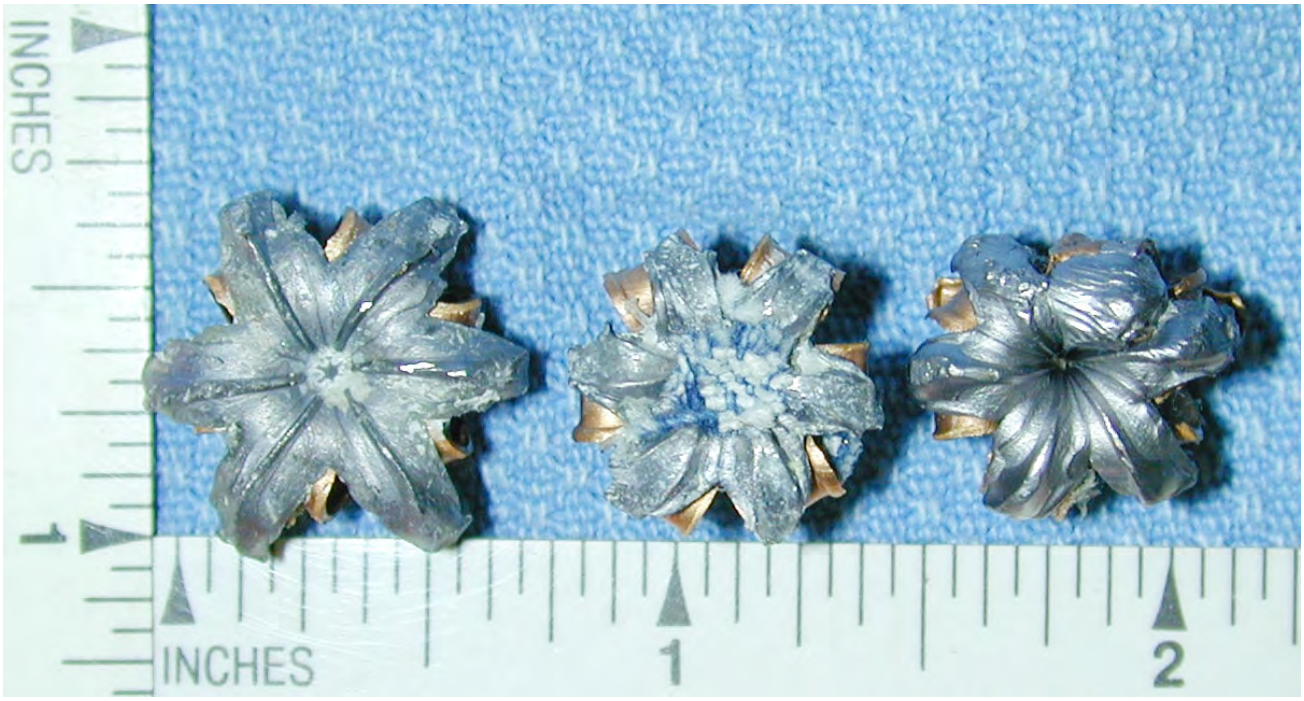
SERVICE PISTOL CONSIDERATIONS:

When comparing well designed duty handgun ammunition, there are minimal differences in penetration depths and temporary cavity effects when comparing common service pistol calibers, as noted below in the gel shots by Doug Carr. As you increase bullet size and mass from 9 mm/357 Sig, to .40 S&W, to .45 Auto, more tissue is crushed, resulting in a larger permanent cavity. In addition, larger bullets often offer better performance through intermediate barriers. For some, the incremental advantages of the larger calibers are offset by weapon platform characteristics. As is quite obvious from the shots into gel, **NONE** of the common service pistol calibers generate temporary cavities of sufficient magnitude to cause significant tissue damage. Anyone interested in this topic should read and periodically re-read, "**Handgun Wounding Factors and Effectiveness**" by Urey Patrick of the FBI FTU, as this remains the single best discussion of the wound ballistic requirements of handguns used for self-defense.

Keeping in mind that handguns generally offer poor incapacitation potential, bullets with effective terminal performance are available in all of the most commonly used duty pistol calibers—pick the one that you shoot most accurately, that is most reliable in the type of pistol you choose, and best suits you likely engagement scenarios.



Handgun test shots into bare gelatin (BG) provide information on best case performance, but do not typically reflect results seen in actual OIS incidents. A more realistic assessment is the IWBA four layer denim (4LD) test or the FBI heavy clothing test. The 4LD test is NOT designed to simulate any type of clothing--it is simply an engineering test to assess the ability of a handgun projectile to resist plugging and robustly expand. One of the senior engineers at a very respected ammunition manufacturer has commented that handgun bullets that do well in 4LD testing have invariably worked well in actual officer involved shooting incidents. Most handgun bullets recovered from human tissue in surgery or at autopsy tend to look like those same type of projectiles after 4LD testing.



9 mm Federal 147 gr HST recovered from:
BG - 4LD - Human Tissue (through Gore-Tex jacket, fleece vest, cotton shirt)

In the wake of the 1986 FBI incident in Miami, LE agencies began to investigate what criteria should be used to optimize handgun ammunition terminal performance. To help guide that development, the FBI held a series of wound ballistic workshops in 1987 through 1993, inviting leading experts to address the topic. These FBI workshops lead to the establishment of the FBI ammunition testing guidelines—this was good for the public, LE, and ammunition vendors, as it articulated a clear set of performance criteria resulting in more effective and safer ammunition. Ammunition engineers were able to use the new test protocol as a metric to guide bullet design. The first generation of handgun ammunition designed to meet the new FBI terminal performance guidelines included the Federal Hydrashok, Hornady XTP, Remington Golden Saber, first generation Speer Gold Dot, and Winchester Black Talon. These bullets all offered improved penetration to reach the desired 12-18” guidelines and somewhat better intermediate barrier performance, however, they still demonstrated inconsistent terminal performance under some conditions, particularly with heavy clothing and through automobile windshields. As a result, the IWBA began a series of tests to determine what improvements were necessary—this data, along with suggested engineering changes and test protocols, particularly the four layer denim test, was shared with industry. By 1997, many munitions engineers began incorporating these updates into LE handgun ammunition, eventually leading to improved loads like the current Barnes Tac-XP, Federal HST and Tactical, Remington bonded Golden Saber, current generation Speer Gold Dot, as well as Winchester Ranger Talon and Ranger Bonded.

The following loads all demonstrate outstanding terminal performance and can be considered acceptable for duty/self-defense use:

9 mm:
Barnes Tac-XP 115 gr +P JHP (*copper bullet*)
Federal Tactical 124 gr JHP (LE9T1)
Federal HST 124 gr +P JHP (P9HST3)
Remington Golden Saber bonded 124 gr +P JHP (GSB9MMD)
Speer Gold Dot 124 gr +P JHP
Winchester Ranger-T 124 gr +P JHP (RA9124TP)
Winchester 124 gr +P bonded JHP (RA9BA)
Winchester Ranger-T 127 gr +P+ JHP (RA9TA)
Hornady Critical Duty 135 gr
Federal Tactical 135 gr +P JHP (LE9T5)
Federal HST 147 gr JHP (P9HST2)
Remington Golden Saber 147 gr JHP (GS9MMC)
Speer Gold Dot 147 gr JHP
Winchester Ranger-T 147 gr JHP (RA9T)
Winchester 147 gr bonded JHP (RA9B/Q4364)

.40 S&W:
Barnes XPB 140 & 155 gr JHP (copper bullet)
Speer Gold Dot 155 gr JHP
Federal Tactical 165 gr JHP (LE40T3)
Speer Gold Dot 165 gr JHP
Winchester Ranger-T 165 gr JHP (RA40TA)
Federal HST 180 gr JHP (P40HST1)
Federal Tactical 180 gr JHP (LE40T1)
Remington Golden Saber 180 gr JHP (GS40SWB)
Speer Gold Dot 180 gr JHP
Winchester Ranger-T 180 gr JHP (RA40T)
Winchester 180 gr bonded JHP (RA40B/Q4355)

.45 Auto:
Barnes XPB 185 gr JHP (copper bullet)
Hornady Critical Duty 220 gr +P
Federal HST 230 gr JHP (P45HST2)
Federal HST 230 gr +P JHP (P45HST1)
Federal Tactical 230 gr JHP (LE45T1)
Speer Gold Dot 230 gr JHP
Winchester Ranger-T 230 gr JHP (RA45T)
Winchester Ranger-T 230 gr +P JHP (RA45TP)

Recovered from BG

Obviously, clone loads using the same bullet at the same velocity work equally well (ex. Black Hills ammo using Gold Dot or Barnes Tac-XP bullets) Bullet designs like the Silver Tip, Hydra-Shok, and Black Talon were state of the art 10 or 15 years ago. Modern ammunition which has been designed for robust expansion against clothing and intermediate barriers is significantly superior to the older designs. The bullets in the Federal Classic and Hydrashok line are outperformed by other ATK products such as the Federal Tactical and HST, as well as the Speer Gold Dot; likewise Winchester Ranger Talons are far superior to the old Black Talons or civilian SXT's.

When assessing service caliber duty handgun ammunition terminal performance, pay particularly close attention to four layer denim/heavy clothing and automobile windshield performance data.

9 mm Fed 147 gr HST

9 mm BH 115 gr +P Tac-XP

L-R: BG, 4LD, AG

Basically ALL the standard service calibers work when using good quality ammunition.

In the last decade or so, ammo engineers have produced a superb generation of 9 mm projectiles that offer penetration in the ideal range and that are capable of good performance after common intermediate barriers. As many agencies are discovering, modern robust expanding, barrier blind 9 mm ammunition is performing on par with larger caliber handgun loads, but offers substantial fiscal and training benefits. In test after test, most officers demonstrate a higher qualification score when shooting 9 mm compared to other common service calibers. Smaller statured officers and those with small hands tend to shoot better with 9 mm. Service pistols tend to be more durable in 9 mm than those in .357 Sig and .40 S&W. In a time of fiscal austerity, 9 mm ammunition is certainly less expensive. For most LE duties, there are a lot of advantages in carrying a 9 mm: easy to shoot--especially one handed, relatively inexpensive to practice with, lots of bullets immediately on tap. (*When I injured my strong hand a few years ago and lost its use for several months, I found out how much more effective I was using a G19 weak handed compared to a .45 Auto 1911*). **In the near future it is likely that many LE agencies will shift back to 9 mm given the benefits noted above.**

.40 S&W is a widely used caliber and offers a compromise between 9 mm and .45 Auto. .40 S&W was developed at a time when 9 mm JHP loads demonstrated insufficient penetration and poor intermediate barrier capability. .40 S&W offers nearly the same large magazine capacity as 9 mm coupled with the larger mass of the .45 Auto. Unfortunately, .40 S&W is a relatively high pressure cartridge, has a sharp recoil that can be hard for many officers to control, and pistols in this caliber have a decreased service life compared to similar 9 mm handguns. In addition, .40 S&W ammunition is more expensive than 9 mm. A very experienced senior SOF NCO who has battled many of our Nation's foes and who has the distinction of having used 9mm, .40, and .45 Auto pistols in combat during various phases of his career wrote the following superb analysis discussing pistol calibers recently:

"*Not getting into the weapons transition issues from frame design to frame design (it's the reason I love to hate the Glock), the fact of the matter is that the recoil on the G23 crosses the magic line of running the shit out of your pistol. Allow me to explain... Most of the guys mentioned that they can handle the reduced size of the 19 and the recoil increase over the G17 is acceptable. Most of us have also determined that this does NOT cross over to the .40 cartridge. Guys with a firm handle on recoil manipulation can use the G22 and G35 with acceptable results. However when you go down to G26's and G23's, the juice is not worth the squeeze. The recoil is now noticeably effecting times and it's measurable. If you can't effectively control recoil and are wasting time allowing your pistol to settle between shots then this is all a wash and means nothing to you, but if you can apply the fundamentals effectively you will quickly see that you can't run a sub compact 9 or a compact .40 worth a shit. So a decision to accept a larger pistol in order to have an acceptable recoil impulse based upon caliber must be made. The smallest 9mm Glock recoil that I will accept is the G19 and I will not go below the G22 when bumping up to .40.*"

For many years, U.S. military Tier One units used custom .45 Auto M1911 pistols. However, beginning in the mid-2000's the most celebrated U.S. military counterterrorism unit switched from 1911's to modern striker fired pistols. Likewise many LE agencies whose tactical teams carried 1911's have moved away from the pistol in recent years. While a properly customized 5" steel-frame single-stack 1911 in .45 Auto is a superb, unparalleled choice for the dedicated user willing to spend a significant amount of money to get it properly initially set-up and considerable time to maintain it, 1911's are no longer an optimal pistol design for organizations to choose, given the high initial costs and increased maintenance associated with the platform compared to other more modern designs that function just as well. Keep in mind that agencies issuing 1911's will need to ensure access to high level, very experienced pistol-smiths (not *just basic armorers)* trained in servicing combat weapons; such folks require extensive hands on training, demand high prices, and are hard to find. For agencies that want a .45 Auto pistol, but don't want to invest the funds and effort necessary in acquiring and maintaining high quality 1911's, they would be better served with a modern pistol like the S&W M&P45, HK45, or 4th gen G21.

Rather than using larger caliber duty pistols, most CONUS urban LE agencies would be better served by issuing a quality 9 mm handgun (*Glock 17/19, S&W M&P9, or HK P30*) along with good ammunition, and then spending the majority of their efforts on mandating effective, high quality, ongoing firearms training—a good minimum would be 100 rounds per week of dedicated, objective, monitored and scored training shots. The keys are:

-- Cultivate a warrior mindset.
-- Invest in competent, thorough initial training and then maintain skills with regular ongoing practice
-- Acquire a reliable and durable weapon system with adequately trained and equipped armorers to allow ongoing maintenance.
-- Purchase a consistent, robust performing duty load along with a similar practice load in sufficient quantities to allow officers to maintain and improve their skill.
-- Then STOP worrying about the nuances of handgun ammunition terminal performance and focus on training and tactics.

Whatever pistol is selected, make sure to fire at least 500 and preferably 1000 failure free shots through each pistol prior to using it for duty. If a pistol cannot fire at least 1000 consecutive shots without a malfunction, something is wrong and it is not suitable for duty use.

BACK-UP HANDGUNS:

Many small, easily concealed semi-automatic pistols which are recommended for law enforcement backup or concealed carry use fire .380 Auto or smaller bullets. While these small caliber handgun bullets can produce fatal wounds, they are less likely to produce the rapid incapacitation necessary in law enforcement or self-defense situations.

Handguns chambered in .380 Auto are small, compact, and generally easy to carry. Unfortunately, testing has shown that they offer inadequate performance for self-defense and for law enforcement use whether on duty as a back-up weapon or for off duty carry. The terminal performance of .380 Auto JHP's is often erratic, with inadequate penetration and inconsistent expansion being common problems, while .380 Auto FMJ's offer adequate penetration, but no expansion. All of the .380 Auto JHP loads we have tested, including CorBon, Hornady, Federal, Remington, Speer, and Winchester exhibited inconsistent, unacceptable terminal performance for law enforcement back-up and off duty self-defense use due to inadequate penetration or inadequate expansion. Stick with FMJ for .380 Auto or better yet, don't use it at all. The use of .380 Auto and smaller caliber weapons is really not acceptable for law enforcement use and most savvy agencies prohibit them. While both the .380 Auto and .38 Sp can obviously be lethal; the .38 Sp is more likely to incapacitate an attacker when used in a BUG role.

BUG--Infrequently used, but when needed, it must be 100% reliable because of the extreme emergency situation the user is dealing with. Generally secreted in pockets, ankle holsters, body armor holsters, etc... Often covered in lint, grime, and gunk. By their very nature, usually applied to the opponent in an up close and personal encounter, many times involving contact shots. A small .38 Sp revolver is more reliable in these situations than a small .380 Auto pistol, especially with contact shots or if fired from a pocket.

There have been many reports in the scientific literature, by Dr. Fackler and others, recommending the .38 Sp 158 gr +P LSWCHP as offering adequate performance. Please put this in context for the time that these papers were written in the late 1980's and early 1990's--no denim testing was being performed at that time, no robust expanding JHP's, like the Barnes Tac-XP, Federal Tactical & HST, Speer Gold Dot, or Winchester Ranger Talon or Ranger Bonded existed. In the proper historical perspective, the 158 gr +P LSWCHP fired out 3-4" barrel revolvers was one of the best rounds available--and it is still a viable choice, as long as you understand its characteristics.

With few exceptions, the vast majority of .38 Sp JHP's fail to expand when fired from 2" barrels in the 4 layer denim test. Many of the lighter JHP's demonstrate overexpansion and insufficient penetration in bare gel testing. Also, the harsher recoil of the +P loads in lightweight J-frames tends to minimize practice efforts and decrease accuracy for many officers. The 158 gr +P LSWCHP offers adequate penetration, however in a 2" revolver the 158gr +P LSWCHP does not reliably expand. If it fails to expand, it will produce less wound trauma than a WC. Target wadcutters offer good penetration, cut tissue efficiently, and have relatively mild recoil. With wadcutters harder alloys and sharper leading edges are the way to go. Wadcutters perform exactly the same in both bare and 4LD covered gel when fired from a 2" J-frame. When faced with too little penetration, as is common with lightweight .38 Sp JHP loads or too much penetration like with the wadcutters, then go with penetration. Agencies around here have used the Winchester 148 gr standard pressure lead target wadcutter (X38SMRP), as well as the Federal (GM38A) version--both work. A sharper edged wadcutter would even be better... Dr. Fackler has written in Fackler ML: *"The Full Wadcutter--An Extremely Effective Bullet Design"*, **Wound Ballistics Review**. 4(2):6-7, Fall 1999) :

"As a surgeon by profession, I am impressed by bullets with a cutting action (eg. Winchester Talon and Remington Golden Saber). Cutting is many times more efficient at disrupting tissue than the crushing mechanism by which ordinary bullets produce the hole through which they penetrate. The secret to the increased efficiency of the full wadcutter bullet is the cutting action of its sharp circumferential leading edge. Actually, cutting is simply very localized crush; by decreasing the area over which a given force is spread, we can greatly increase the magnitude to the amount of force delivered per unit are--which is a fancy way of saying that sharp knives cut a lot better than dull ones. As a result, the calculation of forces on tissue during penetration underestimate the true effectiveness of the wadcutter bullet relative to other shapes."

Currently the Speer Gold Dot 135 gr +P JHP, Winchester 130 gr bonded +P JHP (RA38B), and loads using the Barnes 110 gr all copper JHP (*for ex. in the Corbon DPX loading*) offer the most reliable expansion we have seen from a .38 Sp 2" BUG; the Hornady 110 gr standard pressure and +P Critical Defense loads also offer good performance out of 2" barrel revolvers.

While the steel J-frames can be a bit too heavy for comfortable all day wear on the ankle, body armor, or in a pocket, any of the lighter weight J-frames are fine for BUG use. Most officers report that shooting J-frames is not too bad with standard pressure wadcutters and 110 gr standard pressure JHP loads, but not so comfortable with the +P loadings. When carrying standard pressure wadcutters in J-frames, many officers find that the flat front wadcutters are hard to reload with under stress, so instead carry JHP's in speed strips for re-loads. There is no reason to go with .357 mag in a J-frame, as the significantly larger muzzle blast and flash, and harsher recoil of the .357 Magnum does not result in substantially improved terminal performance compared to the more controllable .38 Sp bullets when fired from 2" barrels.

For years, J-frames were considered "arm's reach" weapons. With the mild recoil of target wadcutters, officers are actually practicing with their BUG's; when combined with CTC Lasergrips, qualification scores with J-frames have dramatically increased. Now 5 shots rapid-fire in a 6" circle at 25 yds is not uncommon—it is kind of mind blowing watching officers who could not hit the target at 25 yds with a J-frame suddenly qualify with all shots in the black…

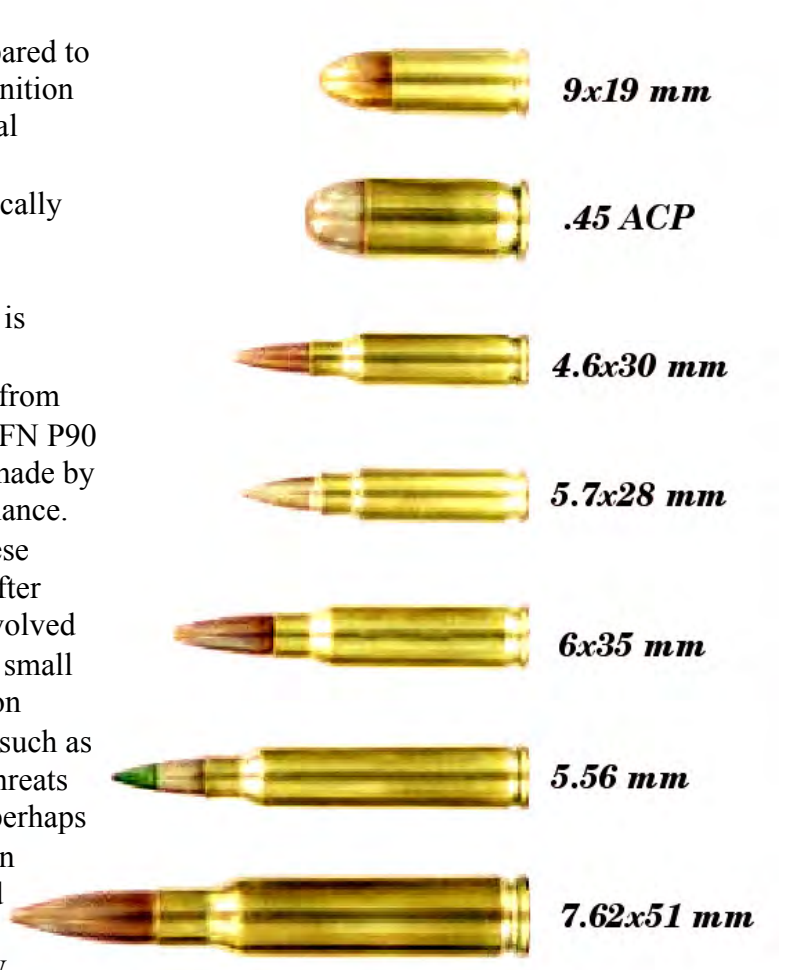
2" J-frames are great BUG's and marginally acceptable low threat carry guns because they are lightweight, reliable, and offer acceptable terminal performance at close range--downsides are difficulty in shooting well at longer ranges because of sight design and sight radius limitations, along with reduced capacity coupled with slower reloading. Nonetheless, with the addition of CTC Laser Grips and an enclosed or shrouded hammer, the 2" J-frame models without key locks *(I personally will NEVER own firearm with an integral lock)* may be the best BUG's and most reliable pocket handguns available.

Another great BUG option if it can be comfortably carried, is a compact 3-3.5" barrel 9 mm pistol like the G26, Sig P239, S&W M&P9c, Kahr PM9, S&W Shield, and Walther PPS, as these offer superior terminal performance compared to either .380 Auto or .38 Sp handguns.

Bottom Line: If you are an LE officer, carry a BUG!!!

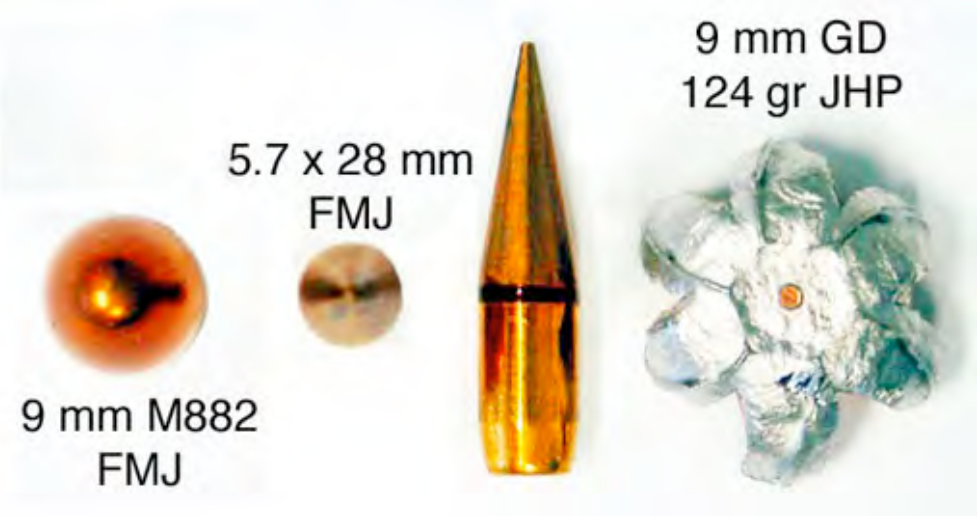
SMG's and PDW's:

While SMG's can improve hit potential compared to handguns, since they fire pistol caliber ammunition SMG's do NOT significantly improve terminal performance compared to handguns—from a terminal ballistic perspective, SMG's are basically large handguns.



The recent trend toward small caliber PDW's is somewhat bizarre. Other than being able to perforate soft body armor, 4.6 x 30 mm fired from the HK MP7 and 5.7 x 28 mm fired from the FN P90 cause wounds less incapacitating than those made by 9 mm handguns—think .22 Magnum performance. Many U.S. LE agencies that have adopted these calibers have quickly reversed this decision after poor terminal performance in OIS (officer involved shooting) incidents. The general use of these small caliber PDW's is a good way to ensure mission failure, except for certain very specific roles, such as executive protection details where potential threats are expected to be wearing soft body armor, perhaps as a compact weapon for personnel working in confined spaces such as armored vehicles and for aircraft pilots, or for certain SOF tasks where the compact, reduced weight of a PDW outweighs the reduced terminal effects.

It is all basic physics and physiology. Look at the surface areas in contact with tissue for 9 mm FMJ and JHP compared to 5.7 mm. When both are point forward, the 9 mm FMJ crushes more tissue than the 5.7 mm; for the short time that the 5.7 mm is at FULL yaw, it crushes a bit more tissue than the 9 mm FMJ. At no time does the 5.7 mm crush more tissue than the expanded 9 mm JHP--even when the 5.7 mm FMJ is at full yaw, an expanded 9 mm JHP crushes more tissue. The relatively small temporary cavities produced by both the 9 mm and 5.7 mm projectiles are not likely to cause



significant injury to the majority of elastic structures of the body. As with any penetrating projectile, if either a 9 mm or 5.7 mm bullet is ideally placed to cause significant damage to the CNS or major cardiovascular organs, a fatal result is likely.

Below are comments specifically on the MP7 by a combat experienced senior SOF NCO currently serving in the U.S. military:

> *"When employing the MP7 up close, you literally use it like a fire hose and sprinkle 4.6 all over the torso of the guy you want to reduce (usually on Auto, which is a CQB no-go anyway), and you have to keep hosing him down with bullets until his brain figures out that you are filling him in. Usually this takes longer than shooting a NSR with a rifle, so by the time that your brain figures out that the guy has quit and is crumpling, you are almost out of bullets and any other threats in the room have most likely started to engage you. IF your team is on their **** and everyone grasps the true importance of primary/secondary sectors of fire, then perhaps you can get in there and all of your guys can sprinkle 4.6 liberally on all of the bad guys in an efficient manner, but if you fail to do that, then bad things will happen quickly."*

Pat Rogers, a former NYPD officer and combat veteran Marine, is a highly respected firearms trainer who has also commented on the use of small caliber PDW's like 4.6 and 5.7 mm:

> *"Multiple rounds are required to incapacitate. This means significantly more training, which translates into significantly more ammunition expended, at a higher cost per round and with limited sources available. To ensure immediate incapacitation, brain shots will need to be emphasized. Which requires more training, and also more insertion of luck into the equation- especially dealing with multiple opponents. Limited capability within the system means engagement at anything outside of CQB distances may be problematic. This means movement to objective, egress etc will present a whole new range of difficulties. The gun is easy to shoot and fun as well. This does not always translate well to real world applications. If there is a single reason why these platforms are in any way superior to the M4 FOW, it is not apparent to me."*

A decorated, experienced SWAT officer at a U.S. LE agency that has had multiple OIS incidents with 5.7 mm FN P90's has written the following--note that his comments equally apply to the 4.6 mm MP7:

> *"The 5.7 pistol as a carry gun is a mistake. There are far more effective weapons and ammunition combinations out there. The only factor that comes close to equalizing the P90 (not the 5.7 pistol) is it's full auto capability: 900 rpm of very controllable fire. Even this advantage is limited to close-in, CQB type engagements. I can put more rounds on target faster with the P90 than with my M4 in close contact engagements. Unfortunately you may HAVE to put more rounds in the threat due to the lack of damage the projectile causes. The 5.56 is far more effective at getting the attention of men than 5.7 mm. This is not speculation. We have been using 30 P90's for five years now. There have been multiple BG's shot with them. We will not be buying more 5.7 mm or other small caliber PDW systems.*

- 30 P90's for five years
- 100,000 rounds per year through those weapons
- very reliable weapon
- very user friendly
- very easy to shoot
- everyone happy
- three OIS's later and some unbelievably poor terminal ballistic performance we dropped them...quickly.
- *22+ OIS shootings using AR-15's with .223...everyone happy (except the 21 dead bad guys).”*

As a result of poor terminal performance, a large Federal agency is also no longer running P90’s like they used to. Likewise, some military units that tried small caliber PDW's in combat are procuring other options, like 9" .300 Blackout uppers to run on M4 lowers.

When a civilian LE agency chooses a full-auto system, significantly more time is needed for training. This increases costs, both in the amount of ammunition necessary to purchase, as well as the need to pay officers for increased time in training, rather than being in the field. Instead of a 1-5 shot NSR with an AR15 based system, with an MP7 each officer is now going to be routinely shooting 15-20+ rounds into each target both in training and in actual OIS incidents, thus the amount of ammo expended is going to be 4 times what would be used with an AR15 based system shooting any common CQB caliber like 5.56 mm, .300 Blackout, 6.8mm, or even 7.62x51mm. How is an LE agency going to afford four times more training ammo for a weapon system like the P90 or MP7 that needs to be always shot full auto and whose ammo is more expensive than other common calibers?

In the civilian realm, how is an LE agency going to explain to their Admin and media why they are now needing to shoot every suspect 15-20+ times? In addition, when you are having to shoot 15-20 rounds full-auto at every target, there is a higher likelihood that some of those rounds may miss the target; how is an LE agency going to handle the liability from the potential increased number of missed shots that can occur with a system that needs to be used full-auto like a *"fire hose"* in order to offer adequate incapacitation of threats?

With the data now available, a U.S. LE agency would have to be woefully ignorant or colossally stupid to purchase a small caliber PDW for SWAT use given the numerous weapon systems available for LE SWAT/CQB use that are both better and more cost effective than small caliber PDW's.

If compact SBR's are desired, consider using AR15 lower receivers with 11-12" barrel 5.56 mm uppers, 8-12” barrel .300 Blackout uppers, or 8-12" barrel 6.8 mm uppers using properly selected good quality barrier blind LE ammunition. For the the best terminal performance consider the new group of 16" .308 rifles like the KAC SR25 ECC, LaRue PredatAR or PredatOBR, or the FN Mk17/ SCAR-H using appropriate LE barrier blind ammunition.

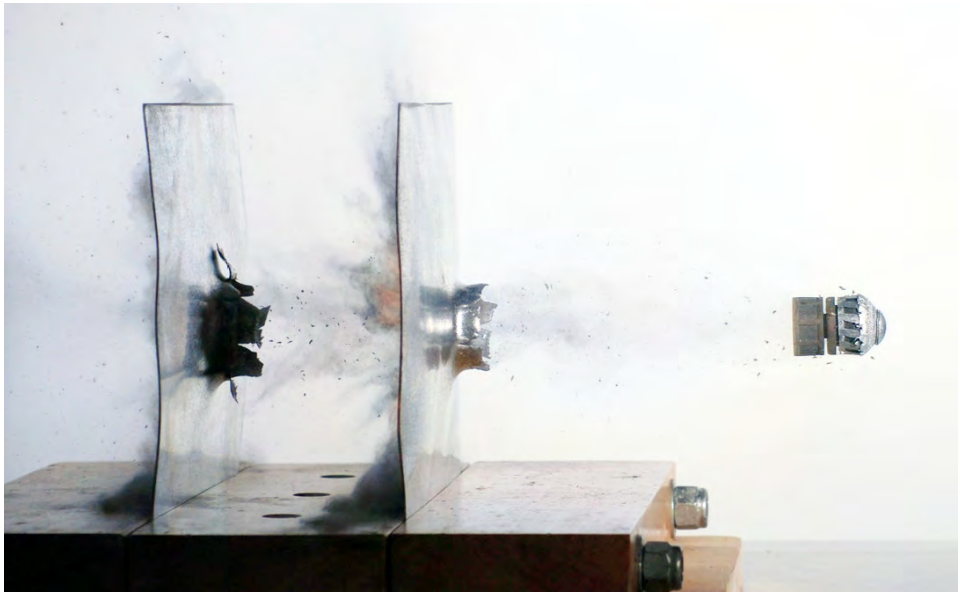
SHOTGUNS:

Until recently, the 12 gauge shotgun has remained the universally accepted shoulder fired weapon for United States law enforcement general purpose use. While law enforcement 12 ga. shotguns are typically loaded with #00 Buckshot and offer outstanding incapacitation potential and increased hit potential against moving targets at close range (no more than 15 to 25 yard), the shotgun is not an ideal general purpose weapon due to its short effective range, imprecise accuracy, downrange hazard to bystanders, small ammunition capacity, slow reloading, and harsh recoil. Recognition of the shotgun's significant limitations as a general purpose weapon have prompted many American law enforcement agencies to adopt the more versatile semi-automatic carbine for general purpose use.

Yet despite their limitations, shotguns are still found in the majority of patrol cars in the United States and still have a valid role for law enforcement use, especially in close quarters combat and to deliver specialized munitions (*breaching, chemical, less lethal impact and electronic*). A basic shotgun weapon system is already in place for most departments and the 12 gauge shotgun is one of the most cost effective weapons to obtain and operate.

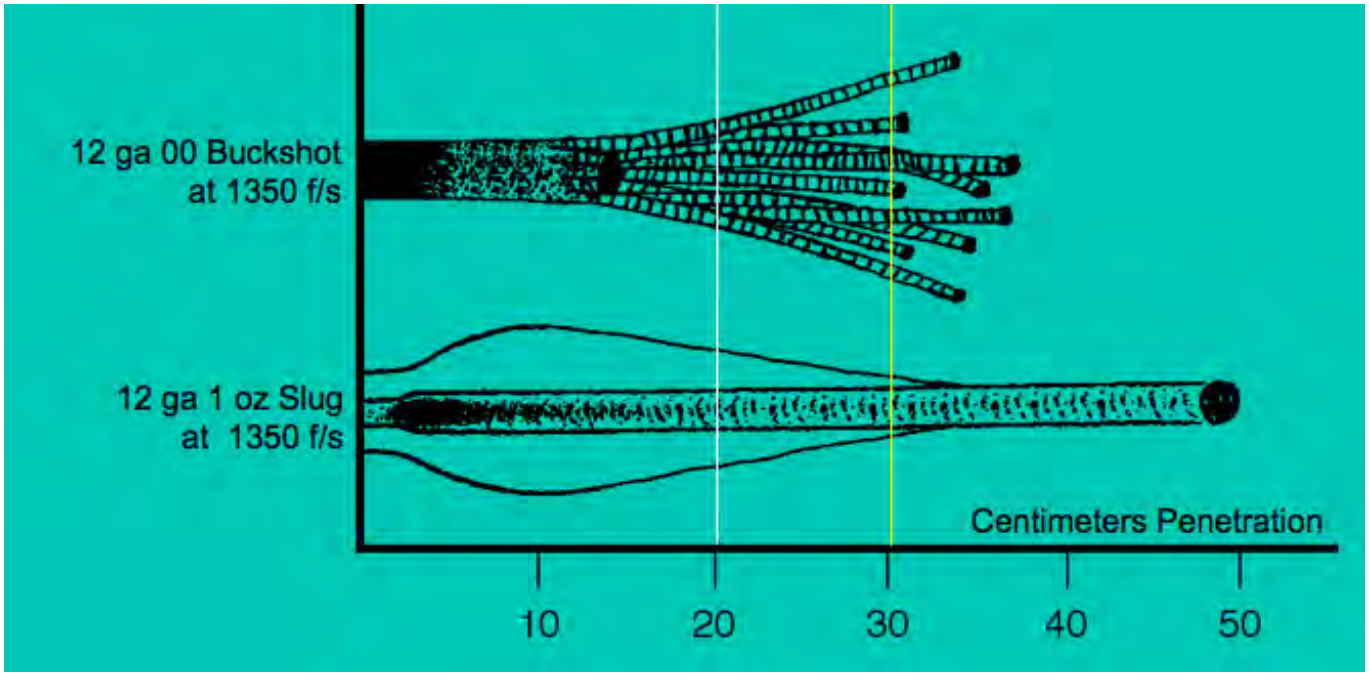
Law enforcement 12 ga. shotguns using buckshot of #1 or larger size offer greater close range physiological incapacitation potential than virtually any other commonly used shoulder fired weapon--this can be a significant advantage during urban entry missions and high risk warrant service in closely confined settings. Should the need arise to stop fast moving targets at close range, like aggressive dogs that could not be deterred through less lethal alternatives, 12 gauge buckshot of #1 shot or larger is the optimal ammunition choice. Keep in mind that buckshot, especially frangible types such as Hevishot, have less ricochet risk than shotgun slugs, as well as handgun and rifle projectiles when fired at objects close to the ground, such as charging dogs. In congested urban settings, buckshot is less likely to pose as high a downrange hazard as slugs in the event a missed shot exits a structure wall. Birdshot offers inadequate penetration and intermediate barrier capability and has no place for LE use.

On the other hand, slugs offer several advantages in other settings, including greater range when in open areas, more precise accuracy and control of projectiles, and in more rural settings if larger animals like cattle are critically injured and need to be rapidly euthanized in the field, shotgun slugs are an optimal choice. Shotguns loaded with good quality deep penetrating slugs like Brenneke or the Federal Truball Deep Penetrator (*PB127 DPRS*) are able to defeat intermediate barriers better than



handguns, SMG's, handgun caliber carbines, & . 223/5.56mm carbines--this particularly includes defeating laminated automobile and transit vehicle windshields. They are also the best option for defense against large U.S. predators like brown bears.

The new Federal #1 buckshot, 15 pellet, 1100 fps "Flight Control" load (LE132-1B) offers IDEAL terminal performance for LE and self-defense use and is the best option for those who need to use shot shells for such purposes. In bare gel, all 15 of the 30 caliber plated pellets penetrate in the 14-18 inch range. Below are patterning shots at 7 and 25 yards fired out of a generic 18" 870P:



5.56 mm BACKGROUND and DISCUSSION:

It is important to keep in mind that the 5.56 mm /.223 cartridge was originally designed for small game varmint hunting. If most hunters avoid it for medium size, 100 + pound game such as deer, why has it been adopted by the military for use on 100 to 200 lbs people?

- improved logistics
- decreased procurement & maintenance costs
- reduced training requirements
- ease of use by people of smaller stature

Not for enhanced lethality or wounding ability!

An analogy may be beneficial: Imagine yourself camping with your family in a wilderness area when suddenly you are confronted with a charging 200 lbs mountain lion intent on devouring your loved ones. What weapon would you want to be armed with at that moment? Obviously, an experienced outdoorsmen would not choose a 5.56 mm / .223 caliber weapon when confronting a dangerous animal, yet we ask our LE officers and military personnel to face foes of similar size who pose an even greater threat, armed with a rifle caliber considered too anemic to reliably stop a similar sized animal assailant.

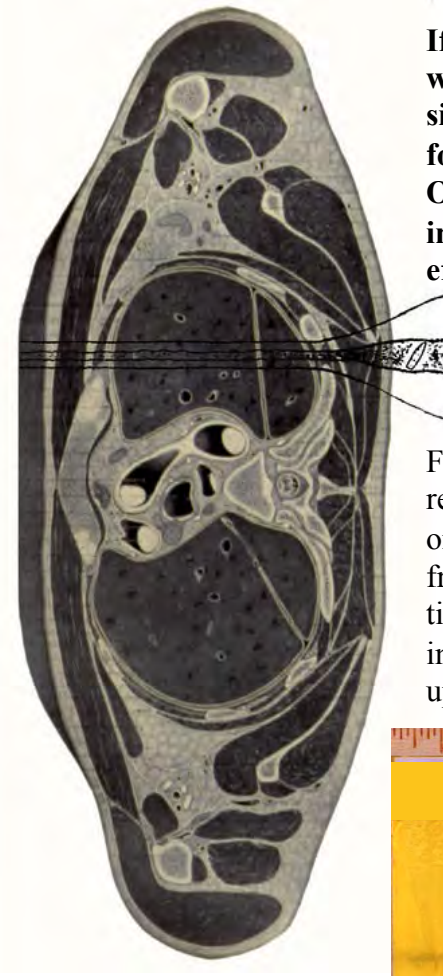
5.56 mm 55 gr M193 FMJ fired from 20" barrel M16A1 rifles was the standard 5.56 mm ammunition in the 1960's and 1970's. Dr. Martin Fackler, the man who has done more research on the 5.56 mm 55 gr M193 FMJ than anyone else on this planet, has written the following (Fackler, ML*: "Literature Review"*. **Wound Ballistics Review**; 5(2):40, Fall 2001) about 55 gr FMJ:

> *"In 1980, I treated a soldier shot accidentally with an M16 M193 bullet from a distance of about ten feet. The bullet entered his left thigh and traveled obliquely upward. It exited after passing through about 11 inches of muscle. The man walked in to my clinic with no limp whatsoever: the entrance and exit holes were about 4 mm across, and punctate. X-ray films showed intact bones, no bullet fragments, and no evidence of significant tissue disruption caused by the bullet's temporary cavity. The bullet path passed well lateral to the femoral vessels. He was back on duty in a few days. Devastating? Hardly. The wound profile of the M193 bullet (page 29 of the Emergency War Surgery—NATO Handbook, GPO, Washington, D.C., 1988) shows that most often the bullet travels about five inches through flesh before beginning significant yaw. But about 15% of the time, it travels much farther than that before yawing—in which case it causes even milder wounds, if it missed bones, guts, lung, and major blood vessels. In my experience and research, at least as many M16 users in Vietnam concluded that it produced unacceptably minimal, rather than "massive", wounds. After viewing the wound profile, recall that the Vietnamese were small people, and generally very slim. Many M16 bullets passed through their torsos traveling mostly point forward, and caused minimal damage. Most shots piercing an extremity, even in the heavier-built Americans, unless they hit bone, caused no more damage than a 22 caliber rimfire bullet."*

Even in the 1960's, there were attempts to improve 5.56 mm effectiveness including the XM287 68 gr FMJ and the IWK 77 gr FMJ--both used in the Stoner 63 by U.S. Naval Special Warfare personnel in Viet Nam; and in the 1970's the 54 gr XM777, as well as the SS109 62 gr FMJ developed by FN for

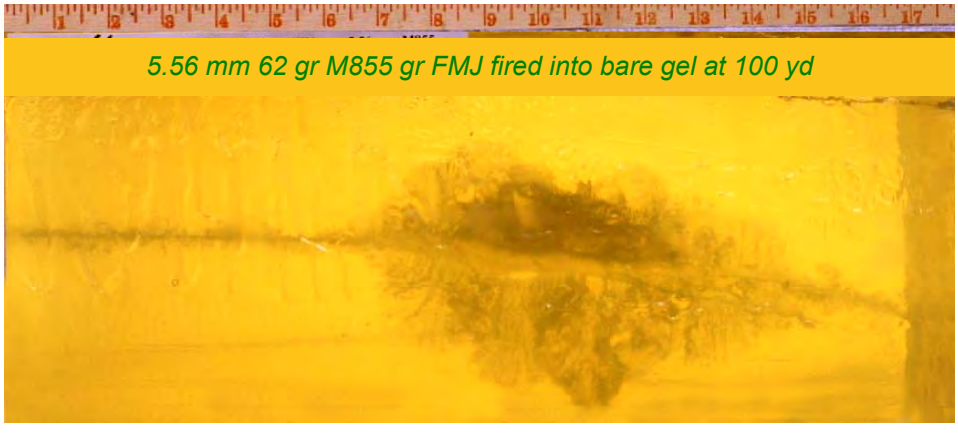
their Minimi LMG. In 1980, the U.S. military decided to adopt the 5.56 mm Minimi as the M249 SAW and the SS109 as the 62 gr FMJ M855 "green-tip". It is important to remember that M855 was designed nearly 35 years ago as linked machine gun ammunition to be fired from the FN Minimi/ M249 SAW while engaging enemy troops wearing light body armor during conventional infantry combat at distances of several hundred meters--while not a perfect solution, M855 does perform adequately in this role. Again, it is critical to recall that M855 was not originally intended for use in carbines or rifles.

Unfortunately, recent LE use and combat operations have once again highlighted terminal performance problems, generally manifested as failures to rapidly incapacitate opponents, during both LE OIS incidents and military combat engagements when M855 is fired from 5.56 mm rifles and carbines, especially those with shorter barrels. Failure to rapidly incapacitate armed opponents is clearly not acceptable, as it jeopardizes mission success and enormously increases the risk of U.S. personnel, as well as innocent civilians, being injured or killed. The disturbing failure of the 5.56 mm caliber to consistently offer adequate incapacitation has been known for nearly 20 years. Dr. Fackler's seminal research at the U.S. Army Letterman Institute of Research Wound Ballistic Laboratory during the 1980's illuminated the yaw and fragmentation mechanism by which 5.56 mm FMJ bullets create wounds in tissue.



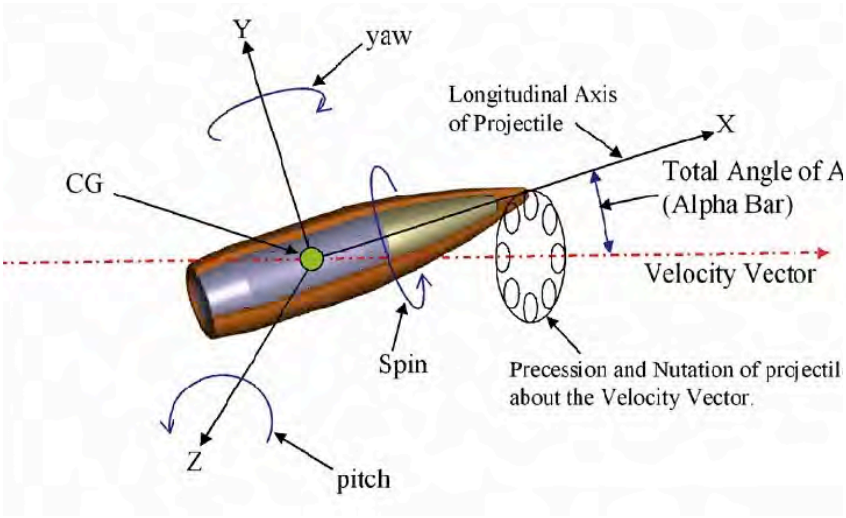
If 5.56 mm bullets fail to upset (yaw, fragment, or deform) within tissue, the results are relatively insignificant wounds, similar to those produced by .22 long rifle bullets--this is true for ALL 5.56 mm bullets, including both military FMJ and OTM (open tip match), as well as civilian JHP/JSP designs used in law enforcement. As expected, with decreased wounding effects, rapid incapacitation is unlikely: enemy soldiers may continue to pose a threat to friendly forces and violent suspects can remain a danger to law enforcement personnel and the public.

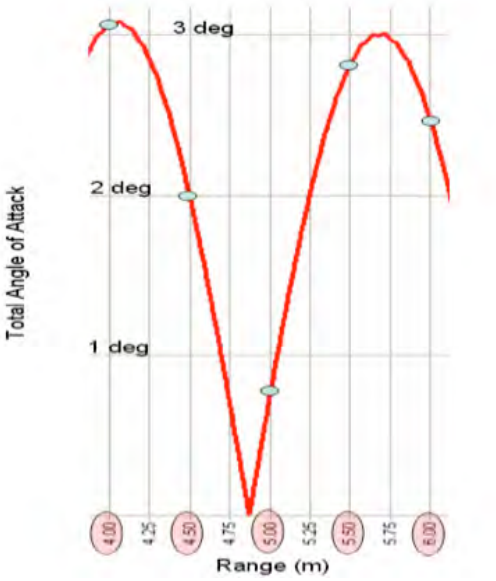
Failure of 5.56 mm bullets to yaw and fragment can be caused by reduced impact velocities as when fired from short barrel weapons or when the range to the target increases. Failure to yaw and fragment can also occur when the bullets pass through only minimal tissue, such as a limb or the chest of a thin, small statured individual, as the bullet may exit the body before it has a chance to upset.



5.56 mm 62 gr M855 gr FMJ fired into bare gel at 100 yd

Two other yaw issues: Angle-of-Attack (AOA) at impact variations between different projectiles, even within the same lot of ammo, as well as AOA variations caused by differences rifles--referred to as Fleet Yaw, were elucidated by the U.S. Joint Service Wound Ballistic Integrated Product Team (JSWB-IPT) during their landmark studies from 2002-2006.





Both AOA at impact and Fleet Yaw refer to the angle between the flight axis of the projectile and the geometric axis of the projectile at the moment of impact. These yaw issues were most noticeable at close ranges and were more prevalent with certain calibers and bullet style--the most susceptible being 5.56 mm FMJ ammunition like M855 and M193. As a result of inconsistent initial yaw cycles, some ammunition, including military issue 5.56 mm M855 and M193 FMJ, can offer unexpectedly poor terminal performance. What this means is that two shooters firing the same lot of M193 or M855 from their M4's with identical shot placement can have dramatically different terminal performance results: one shooter states that his ammo is working great and is effective at dropping bad guys, while the other complains his opponents are not being incapacitated because the bullets are zipping right through the targets without upsetting. Both shooters are telling the truth…

Impact yaw alters terminal effects of U.S. 5.56 mm M855 62 gr "green tip" FMJ

M855 w/2.5 degree AOA @ impact

M855 w/0.5 degree AOA @ impact

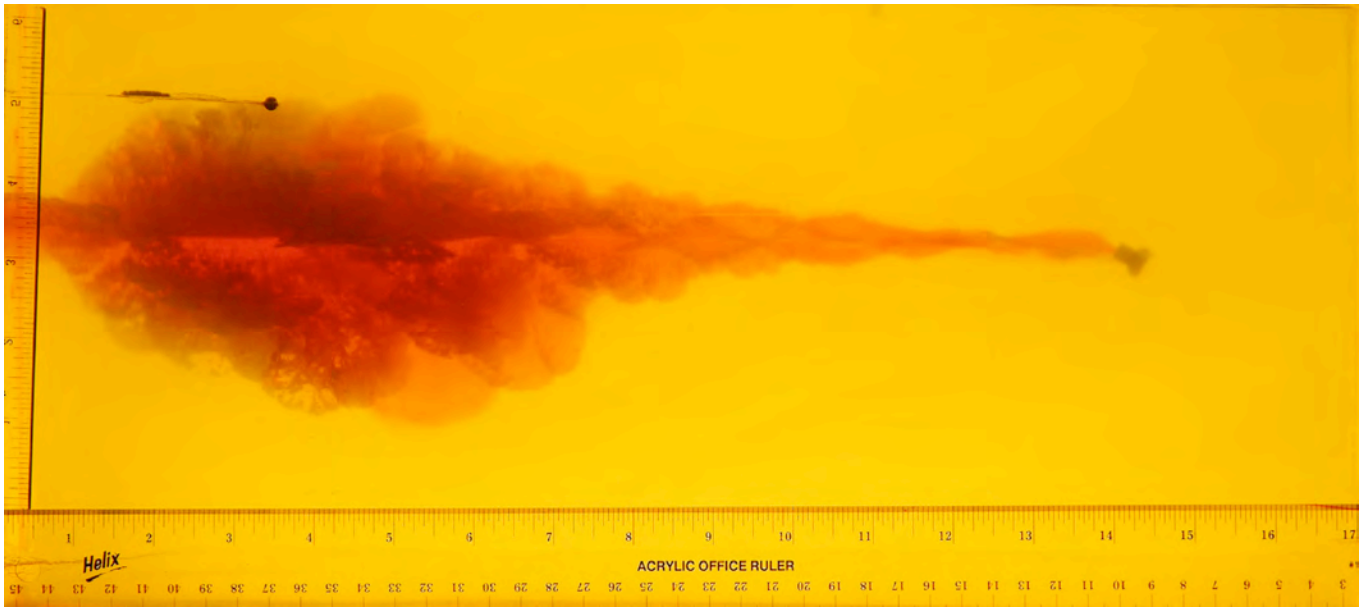
An impact AOA greater than roughly 2 degrees enhances close range terminal effectiveness. However, large initial AOA's reduce down range velocity and decrease accuracy potential.

It is critical that LE duty ammunition offer terminal performance that is impact yaw independent to avoid inconsistent, ineffective terminal effects.

Recent efforts to improve 5.56 mm ammunition terminal performance, most importantly the "Barrier Blind" ammunition requirements from multiple organizations, including the FBI, USMC, NSWC Crane/USSOCOM, & JSOC have yielded several options from industry that appear to effectively address this issue. The FBI was the first organization to specify barrier blind projectiles; over the past decade, the FBI's "barrier blind" projectiles, including the Federal 62 gr TBBC JSP, Winchester 64 gr bonded JSP, and Nosler 60 gr Partition JSP, have demonstrated superior terminal performance in both lab testing and numerous OIS incidents compared to common military issue 5.56 mm ammunition. The 01 June 2006 U.S. Marine Corps RFI for "Barrier Blind" ammunition *(http://www.cbd-net.com/index.php/search/show/1087257*) resulted in development of the ATK 77 gr TOTM (*Tactical Open Tip Match*) projectile that combined the Law of War legal, JAG approved Mk262 nose configuration with the bonded "barrier blind" bullet core construction used in ATK LE ammunition. The ATK TOTM design is an outstanding, simple, adaptive design--projectiles can be manufactured with a traditional lead core or in a lead-free version, bonded or non-bonded. ATK used the basic TOTM design configuration in developing the SOST (*Special Operations Science and Technology*) projectiles for NSWC Crane/USSOCOM, however the initial SOST projectile variants use a less robust, non-bonded core that sacrifices a bit of intermediate barrier capability for reduced production cost. The SOST 5.56 mm 62 gr Mk318 Mod 0 OTM (*Federal T556TNB1*) is optimized for relatively short barrel weapons, uses heat stable, flash suppressed powder, and offers good terminal performance, with early upset and reasonably good intermediate barrier performance for a non-bonded projectile. Mk318 Mod1 is a lead-free version. In addition, U.S. JSOC elements experimented with several blind to barrier projectiles before selecting the Barnes all copper, lead free 70 gr TSX OTM projectile loaded by Black Hills; known as the "Brown Tip" or "Optimized"; this load has proven highly accurate and effective in combat use.

For LE Patrol use, where there is a high incidence of potential engagements around or involving vehicles, ammunition that is able to effectively penetrate intermediate barriers, particularly vehicle glass is critical. **The best LE 5.56 mm/.223 loads for intermediate barrier penetration using 1/9 and faster twist barrels are the 5.56 mm Federal 62 gr Trophy Bonded Bear Claw (TBBC) bonded JSP (XM556FBIT3) and 5.56 mm Winchester 64 gr solid base bonded JSP (Q3313/RA556B) developed for the FBI, along with the outstanding new Black Hills 5.56 mm 50 gr TSX loading. The Hornady 5.56 mm 55 gr GMX is another acceptable option.**

5.56 mm BH 50 gr TSX OTM fired into bare gel at 3 m from 10.5" barrel



Note that the above loads are all true 5.56 mm loads that require a real milspec 5.56 mm chamber, not a SAAMI .223 chamber--be sure to check with an appropriate gauge or reamer and only use in quality AR15's like those from Colt, BCM, Centurian, FN, LaRue, LMT, etc…

Most other acceptable LE barrier blind loadings are at .223 pressures, including the superb, well proven .223 55 & 62 gr Federal bonded JSP Tactical loads (*LE223T1 & LE223T3*), along with loads using Nosler 60 gr Partition JSP, Remington 62 gr Core-Lokt Ultra Bonded JSP (*PRC223R4*), .223 Federal 55 gr TSX (*T223S*), .223 Horn 55 gr GMX, and the .223 Speer 64 gr Gold Dot JSP's (*and identically constructed Federal 62 gr Fusion JSP and Federal XM223SP1 62gr Bonded JSP*). The Swift 75 gr Scirocco bonded PT is also good choice, but usually requires a 1/7 twist. *Note that the Barnes all copper TSX bullets are great projectiles and offer good penetration through barriers, however, when first hitting a laminated automobile windshield intermediate barrier, most TSX bullets exhibit less expansion than bonded JSP's, as the Barnes jacket either collapses at the nose, the jacket "petals" fold back against the core, or the "petals" are torn off; this results in a caliber size projectile configured a lot like a full wadcutter, leading to deep penetration.* **If running 1/12 twist barrels, as found in 1033 program M16A1's, stick with the BH 50 gr TSX, Fed 55 gr TBBC, Fed 55 gr TSX, Horn 55 gr GMX, or Speer 55 gr Gold Dot.**

NONE of the fragmenting 5.56 mm OTM bullets, even the heavy 75 - 100 gr loads, offer acceptable performance through automobile windshield glass. Contrary to what many believe, M193, M855, M855A1 FMJ are not very good against glass; the best military 5.56 mm load against glass is 52 gr M995 AP, followed by the 62 gr Mk318 Mod0 OTM and 70 gr Optimal "brown tip" OTM.

In those situations where intermediate barrier penetration is not a critical requirement, for example LE urban entries or long range shots in open conditions, then OTM, JHP, and standard JSP loads can offer acceptable performance. For 1/7 twist barrels, the Hornady 75 gr OTM, Nosler 77 gr OTM, and Sierra 77 gr SMK OTM are all good choices. The experimental BH loaded 100 gr OTM exhibits impressive fragmentation, even at relatively low velocities, however while capable of shooting out to 600, it is optimized for 200 and under. If stuck with 1/9 twist barrels, the heavy 70+ gr loads are not universally accurate in all rifles and the 69 gr SMK OTM, the 68 gr Hornady OTM, the Winchester 64 gr JSP (RA223R2), the Federal 64 gr TRU (T223L) JSP, Hornady 60 gr JSP, are likely to run accurately in the majority of 1/9 twist rifles. **Again it is critical to keep in mind that the above loads fail to offer adequate penetration through intermediate barriers.**

For longer range engagements using precision weapons like the Mk12 SPR or DMR rifles with faster 1/8 or 1/7 twist barrels, one of the combat proven 5.56 mm (*ie. 5.56 mm NATO pressure loads, not the .223 SAAMI pressure loads which run about 200 f/s slower*) heavy OTM loadings are a good choice: the Barnes 70 gr TSX (*Optimized "browntip"*), Hornady 75 gr TAP (*#8126N*), Nosler 77 gr, or the Sierra 77 gr Match King (*Mk262 Mod1*).

Short barreled 5.56 mm weapons, such as the Colt Commando, Mk18 CQBR, HK416, HK53, HK G36C, etc… offer advantages in confined spaces. With SBR's it is best to stick with the barrier blind loads recommended above, although the heavy OTM's suggested for long distance shooting will also work. SBR's can run into rotational velocity issues with some loads, so it is generally best to select faster 1/7 twist barrels whenever possible. Remember, with SBR's, effective engagement distances are significantly reduced compared to the longer barreled carbines.

Keep in mind, that with non-fragmenting bullet designs, heavier bullet weights are not necessarily better, especially at closer ranges and from shorter barrels. As long as penetration and upset remain adequate, it is possible to use lighter weight non-fragmenting bullets and still have outstanding terminal performance. With fragmenting designs, a heavier bullet is ideal, as it provides more potential fragments and still allows the central core to have enough mass for adequate penetration. In addition, heavier bullets may have an advantage at longer ranges due to better BC and less wind drift.

Whatever projectile is used, it is best with a cannelure to prevent bullet set-back in semi-auto/auto weapons. Also, be cautious with the exposed lead on some JSP designs. Often they will run great for up to 200-300 rounds, but then mysterious feeding failures will begin as a result of lead build-up on the feed ramps. I have personally seen this occur with a variety of JSP's including 55 gr, 60 gr, and 64 gr in LE training courses. As soon as FMJ or OTM was substituted, all the feeding failures ceased.

Be sure to watch your ammo storage conditions. Temperatures above 150 deg F will degrade the powder and cause pressure spikes. Hint: Think locked metal conex containers in the mid-east, car trunks in the southern U.S., and storage areas near heaters in the northern U.S. Also be cautions of leaving a round in a very hot chamber; besides the obvious danger of a cook-off, the powder can also be damaged by the heat, leading to dramatically increased pressures when the round is eventually fired.

A large SWAT team in this area had a failure to fire from an M4 with Hornady TAP ammo during an entry--fortunately no officers were hurt and the suspect immediately threw down his weapon when the carbine went click instead of bang. After the incident was concluded, the team went to the range and expended the rest of their carbine ammo and had one additional failure to fire. This same team had 3 Hornady TAP rounds fail to fire in training a couple of years ago. When noted trainer Pat Rogers was teaching a class at a nearby agency, there were 5 failures to fire using Hornady TAP ammo. In all 10 cases, there appeared to be good primer strikes, but no rounds fired. On analysis, the ammunition had powder and checked out otherwise. It would be easy to blame the ammunition for these failures.

However, despite what appeared to be good primer strikes, two problems were discovered. First, when accurately measured, some of the primer strikes had insufficient firing pin indentations due to faulty weapons. The failed round from the potential OIS incident had a primer strike of only .013"—the minimum firing pin indent for ignition is .017". In addition, the primers on the other rounds were discovered to have been damaged from repeated chambering. When the same cartridge is repeatedly chambered in an AR15, the floating firing pin lightly taps the primer; with repeated taps, the primer compound gets crushed, resulting in inadequate ignition characteristics--despite what appears to be a normal firing pin impression.

The problems with repeatedly chambering a round has been noted in OCONUS combat the past decade, as well as with other USG organizations.

Once a round has been chambered in a weapon, Do NOT re-chamber it for duty use. Do NOT re-chamber it again, except for training. This is CRITICAL for both rifles as well as handguns!!!

There appears to be significant confusion regarding the terminal effects of “frangible” ammunition and its efficacy for duty/self-defense use.

The first task is to define what exactly is meant by “frangible” ammunition. Frangible projectiles are specifically designed to break apart into small dust like particles when hitting hard structures--typically steel targets, and generally fall into two categories: training ammunition and Reduced Ricochet, Limited Penetration (RRLP or R2LP) loads. It is important to note that although frangible ammunition ideally disintegrates against a hard steel target, that does NOT mean it will break apart against/within less dense materials, including soft tissue.

Various types of frangible training ammunition have been available since WWII. Frangible training ammunition allows safe close-range training events when using steel targets, reduces the danger of wall penetration in indoor shoot houses using steel bullet traps, and can result in less airborne lead contamination, as most frangible projectiles do not contain lead. Frangible training ammunition is frequently not as functionally reliable or accurate as duty ammunition. In testing, 9mm 87gr Greenshield frangible ammunition with velocities of nearly 1600 f/s was able to fully perforate soft armor, but would completely shatter against 5 mm steel plate with no visible damage to the steel. It would chunk out a 3 inch deep divot when fired against a reinforced concrete wall, yet in tissue it acted like 9mm FMJ, with no deformation or fragmentation and 22-24 inches of penetration. Likewise, Federal .223 26 gr frangible training ammunition fragmented completely against steel, easily penetrated soft body armor, but in soft tissue created wounds of no greater severity than seen with a non-deforming .22 LR projectile.

Reduced Ricochet Limited Penetration loads are typically intended for CQB operations where significantly reduced ricochet and limited penetration potential around shipboard bulkheads or industrial pipes is necessary in order to reduce risk to innocent persons and friendly force personnel, as well as to reduce the risk of release of hazardous industrial and/or other dangerous materials. For example, for its intended niche role the Black Hills Mk255 Mod 0 5.56 mm 62 gr R2LP (*AA17*) ammunition offers good unobstructed soft tissue terminal performance on par with other military 5.56 mm loads, but is not ideal for general CQB or land warfare use do to difficulties defeating glass and other commonly encountered intermediate barriers. RRLP ammunition may be of benefit for personnel conducting VBSS, GOPLAT, and *in extremis* missions in maritime environments or industrial settings with hazardous materials. Likewise, the use of frangible training ammunition is an important safety consideration for close range exercises using reactive steel targets. **On the other hand, frangible training ammunition is NEVER a good choice for duty/self-defense use!** *Anyone recommending frangible training ammunition for duty/self-defense purposes is grossly misinformed or is ignorantly repeating specious gunrag myth and should be disregarded as a source of valid information…*

Many California LE agencies have used the Hornady 75 gr TAP OTM, Winchester 64 gr JSP (*it has been on the state contract for very low cost*), and the similar Fed 64 gr JSP TRU load (*223L*)--all have worked well in actual officer involved shootings against unobstructed targets. However in the wake of serious terminal performance failures by non-bonded .223 64 gr JSP's due to inadequate penetration into vehicles during several OIS incidents since 2010, quite a few agencies have been switching to general issue of Barrier Blind loads like the 55 & 64 gr Gold Dot loads, along with the 55 & 62 gr TBBC loads that previously saw more limited use. **Without a doubt, barrier blind loads are a prudent choice for routine LE use; frangible loads are not.**

.300 AAC Blackout:

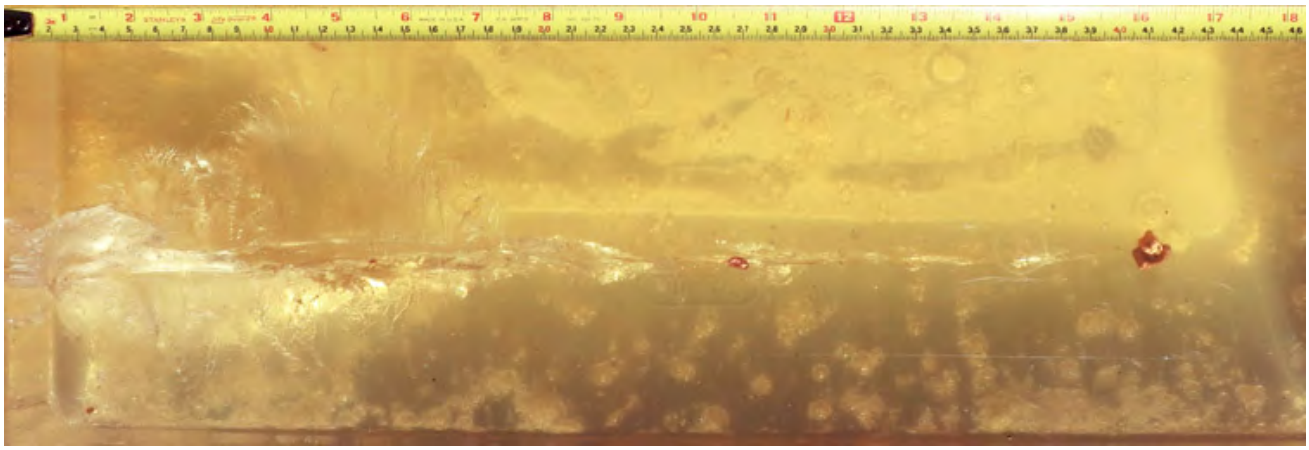
The .300 AAC Blackout is a new update of the proven .300 Whisper/.300 Fireball calibers that use a 5.56 mm cartridge case opened up to allow a .30 caliber projectile to be seated. These offer both extremely quiet subsonic performance in suppressed weapons, as well as supersonic performance similar to that of 7.62x39 mm, but in a format that is more reliable when fired from AR15 type weapons. The .300 BLK is optimized for use in 8-16" barreled weapons.

Subsonic loadings typically use a 220 gr SMK; these are primarily for military use.

5.7, 5.45, 5.56, .300 BLK, 6.8, 7.62x39, 7.62x51

With supersonic loads, the .300 AAC Blackout has great potential for LE Patrol and entry team use, but needs purpose built bullets, as most current .30 caliber bullets are designed for the much higher velocities of .308/.30-06/.300 Win Mag and are thus not optimally performing at the lower velocities of the .300 BLK. Early upsetting, barrier blind loads with good weight retention and optimal penetration depth (12-18") need to be introduced specifically for the .300 BLK velocity range.

Recently, loads using the purpose built Barnes 110 gr TTSX have been introduced. Loads using the TTSX perform very well, however, penetration is a bit deeper than ideal for CONUS LE use--much like the 5.56 mm 70 gr TSX. The .300 BLK 110 gr TTSX is a great load for military GP use and a superb load for hunting. A perfect barrier blind LE load should ideally offer penetration in the 12-18" range; perhaps something like a Remington CLUB, Speer Gold Dot, or Federal TBBC design will optimize the .300 BLK for LE purposes.



***.300 BLK Rem 110 gr TTSX at 2250 f/s**; AG: Pen=17.0", RD= 0.58", RL=0.22", RW=65.4gr*

Barnes 300 AAC BLK 110gr TTSX

Bare Gel

Penetration	Avg. dia.	Rtd. Wt.
20.5"	0.585"	98%

Heavy Clothing

Penetration	Avg. dia.	Rtd. Wt.
21.1"	0.594"	98.7%

Steel (car door)

Penetration	Avg. dia.	Rtd. Wt.
18"	0.663"	98%

Wallboard

Penetration	Avg. dia.	Rtd. Wt.
19.0"	0.586"	93.4%

Plywood

Penetration	Avg. dia.	Rtd. Wt.
18.6"	0.595"	86.9%

Glass (windshield)

Penetration	Avg. dia.	Rtd. Wt.
16.6"	0.498"	77.5%

Bare Gel @ 100 yards

Penetration	Avg. dia.	Rtd. Wt.
19.7"	0.581"	98.3%

Bullet: Barnes 300 AAC 110gr TTSX
Average muzzle velocity: 2186 ft/s
Test Weapon: 9" 300 AAC BLK
Average for three shots on each test

6.8 mm for LE use:

For LE purposes, the 6.8 mm potentially allows an agency to use one caliber for all their shoulder fired weapons. Not only does 6.8 mm caliber offer substantially better terminal effects and intermediate barrier penetration capability than 5.56 mm, it is also an inherently very accurate cartridge. In addition, the 6.8 mm was designed and optimized to work effectively in short barrels of 12 to 16 inches in length. At present time, the best 6.8 mm projectiles for LE use in barrels from 12-16" are the Federal 90 gr Gold Dot JSP, Nosler 100 gr Accubond PT, Hornady 110 gr OTM, Barnes 85 gr TSX OTM, and Remington 115 gr Core Lokt JSP. If a reduced penetration load is needed, the 110 gr Hornady VMAX and 90 gr Speer JHP's work.

The 6.8 x 43 mm SPC, jointly developed by 5th Special Forces Group and USAMU in conjunction with USSOCOM, built on the last 100 years of historical ballistic data in creating what may be the perfect COTS refinement of the long standing hypothesis that a 6.5 to 7 mm bullet is the ideal choice for combat and duty use. 6.8 mm combines the best features of both the 7.62 x 51 mm "battle rifle" cartridge and the 5.56 mm "assault rifle" cartridge without either of their deficits. In addition, the 6.8 mm offers superior accuracy and incapacitation potential compared to the 7.62 x 39 mm cartridge fired by the AK47 rifle commonly used by many potential threats.

Unlike 5.56 mm NATO and 7.62 mm NATO weapons, the 6.8 mm was designed from the beginning to offer optimal performance in the 12-16" short barreled carbines favored by U.S. forces working in urban settings and from vehicles. During SPC development different bullet diameters of 6 mm, 6.5 mm, 6.8mm, 7 mm, and 7.62 mm were tested, using multiple bullet types, shapes, and weights from 90 to 140 gr--the 6.8 mm was selected because it offered the BEST combination of combat accuracy, reliability, and terminal performance for 0-500 yard engagements in an M4 size package.

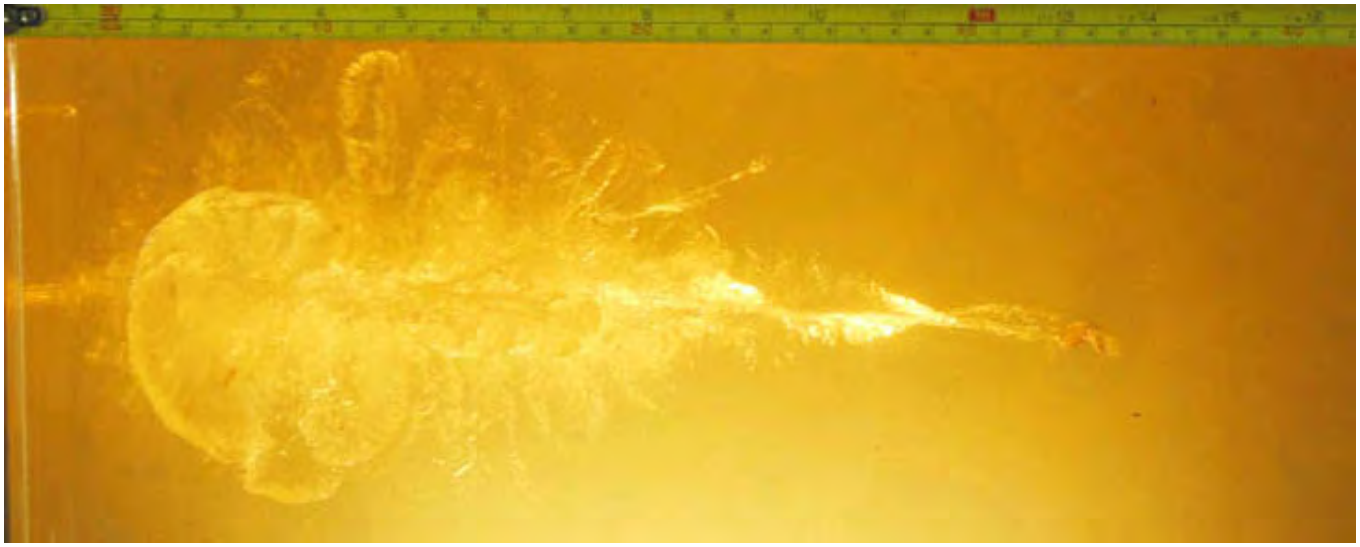
Current accuracy, terminal ballistic, and operator testing indicates that the 6.8 mm SPC is extremely accurate and offers superior terminal performance from CQB to medium ranges (*0 to 500 meters*) as compared to ALL available 5.56 mm ammunition. The 6.8 mm has repeatedly demonstrated outstanding terminal performance in JSWB-IPT testing, FBI BRF testing, USMC testing, and the July 2008 CTTSO/TSWG MURG Congressional demonstration. In addition to offering outstanding terminal performance, 6.8 mm is also an inherently very accurate cartridge, even when fired from short barrel weapons. Using the 6.8 mm 12" barrel MURG configuration with a 4x ACOG optic, U.S. military SOF personnel shot 8" groups at 600 yards using 6.8 mm 115 gr OTM fired at 2434 fps. Likewise, this year a combat experienced allied SOF soldier shot one of the new 8" LWRCI Six8 piston carbines with a 4x optic firing the Federal 90 gr Gold Dot JSP and made first round hits on 6" steel targets arrayed from 400-600 yds.

In April of 2006, after a four year, $6 million research project assessing 54 different weapon systems in 8 calibers, the JSWB-IPT wrote:

- *"The 6.8 mm performance observed in this test suggests that an intermediate caliber is the answer to the trade-off balance issue."*
- *"The 6.8 mm projectile had a near optimal balance of MASS, VELOCITY, and CONFIGURATION to maintain its effectiveness, even at a lower impact velocity."*
- *"The 6.8 mm SPC is far and above, the best performing ammunition…"*

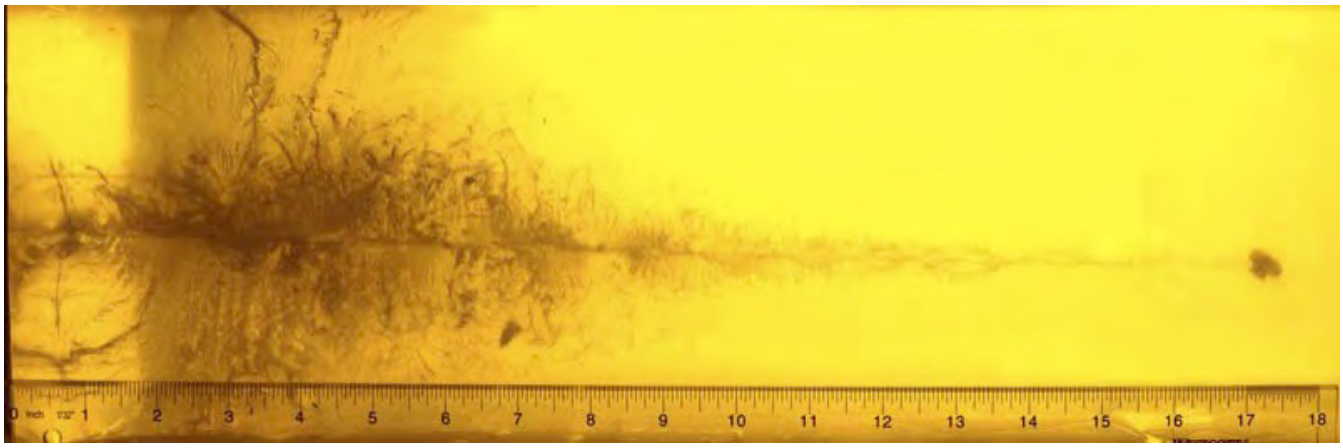
As further confirmation, the 2011 ARDEC conducted "Caliber Study" evaluated identical solid copper and exposed steel tip projectiles in calibers .224, .243, .257, .277 and .30--demonstrating that the .277 projectiles generally outperformed the other calibers in almost all of the test metrics.

Upgrading to 6.8 mm offers substantial fiscal advantages over other solutions, as the increase in weapon effectiveness over current 5.56 mm rifles and carbines is achieved for minimal procurement costs. The 6.8 mm can be easily and rapidly retrofitted to existing 5.56 mm weapons (Mk18, HK416, Mk16/SCAR-L, M4, Mk12, M16). Fortunately, 6.8 mm magazines holding 26-30 rounds have the same external dimensions as current standard issue 30 rd. 5.56 mm M4/M16 magazines allowing continued use of all current load bearing equipment and magazine pouches when upgrading to 6.8 mm weapons. In addition, for a foreign military customer, LWRCI has developed a 6.8 mm piston AR15 with slightly enlarged magazine well designed to use the new Magpul 6.8 mm polymer mag.



6.8 mm Horn 115 gr OTM in BG: vel=2597 f/s, pen=13.8", TC=5" max diam 4.5" depth from 1-9" pen

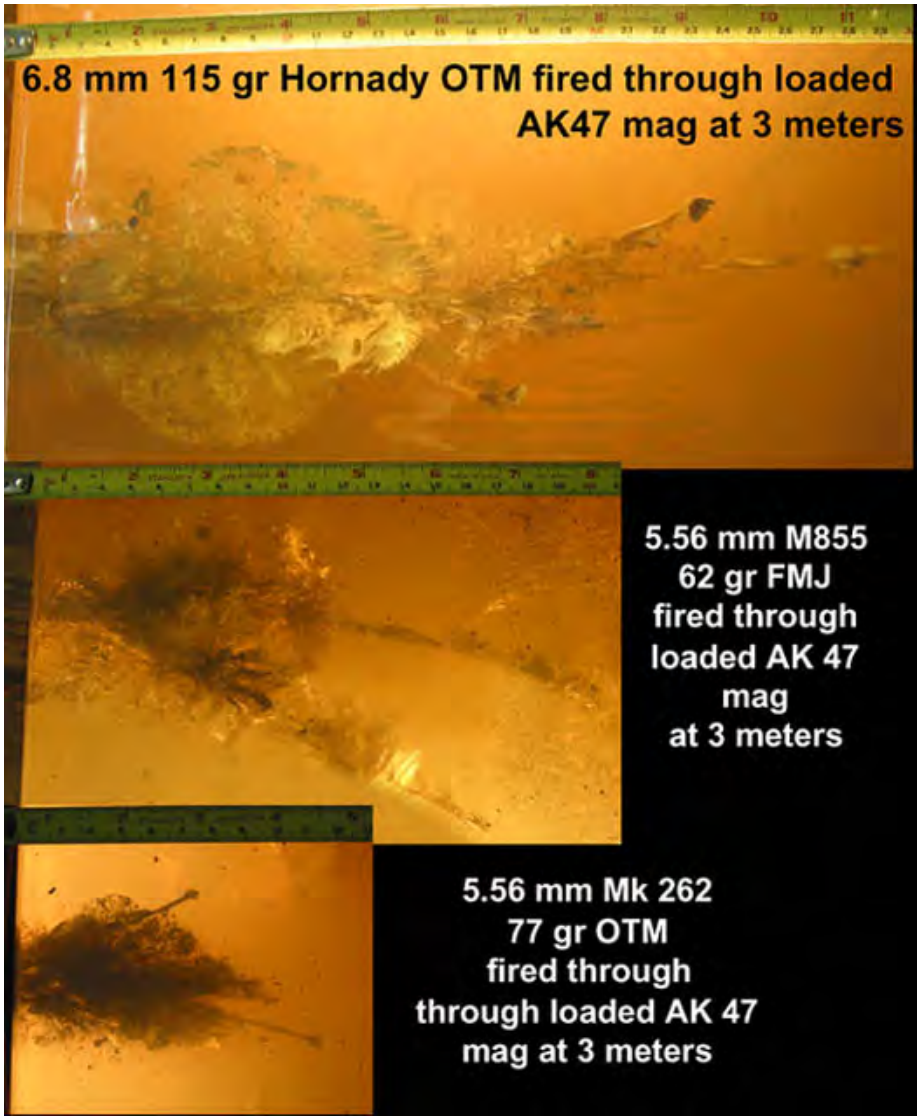
As an additional cost savings, with the AR15 platform, end-users can have two identical uppers, one in 5.56 mm for training and one in 6.8 mm for duty use. Since there are NO differences between using a 5.56 mm and 6.8 mm AR15 when it comes to mag changes, malfunction clearance, shooting positions, etc... end-users can take advantage of inexpensive/free issued 5.56 mm ammunition for rote training needs and save the more expensive, quality 6.8 mm duty ammo for real world use--obviously after shooting sufficient 6.8 mm to ensure function and establish a good zero with the 6.8 mm upper



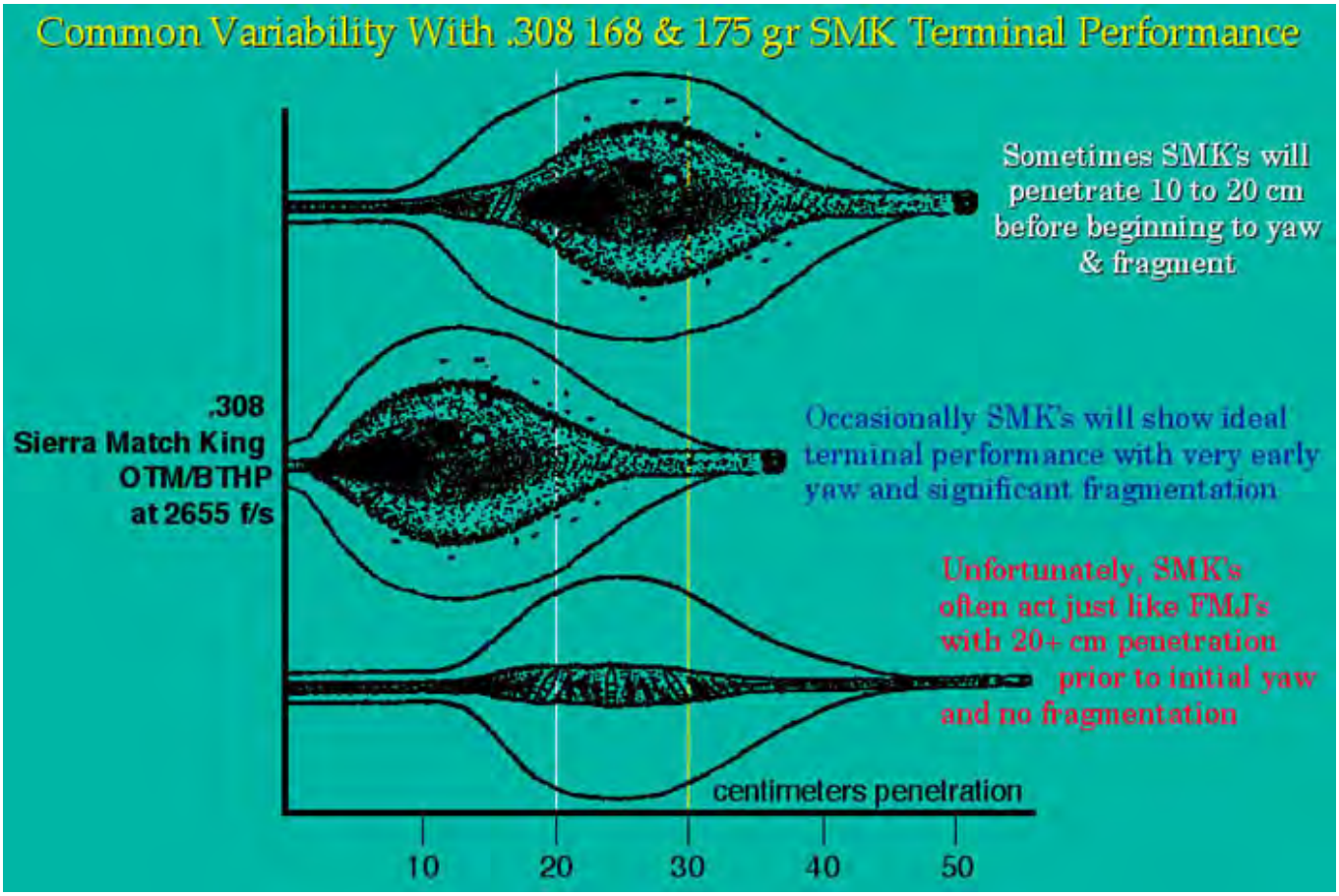
6.8 mm SSA 85 gr Barnes TSX OTM in BG: vel=3099 f/s, pen=17.5", TC=4.75" max diam@4" depth from 1.5-8.5" pen

LE use of .308:

There has been a significant amount of scientific testing yielding repeatable, verifiable, irrefutable factual data rather than mere opinions. For a LE perimeter role, a 5.56 mm AR using appropriate ammunition is probably fine; it might even be OK as a sniper support weapon as long as shots into vehicles or through intermediate barriers are not a common concern. Having said that, as a LE or military true sniper caliber, as contrasted with DMR or patrol/perimeter applications, the 5.56 mm just does not cut it, as there are far better choices: Agencies still using bolt guns can consider a 16-20" .308 and those agencies using more efficient and effective semi-autos can select either a 16" .308 or a 12-16" 6.8. Night vision capability w/ IR laser designator is an operational necessity; ASA data shows 43% (95/219) of sniper incidents occurred at night. Visible lasers are another option that should be strongly considered. Good sound suppressors should also be mandatory.

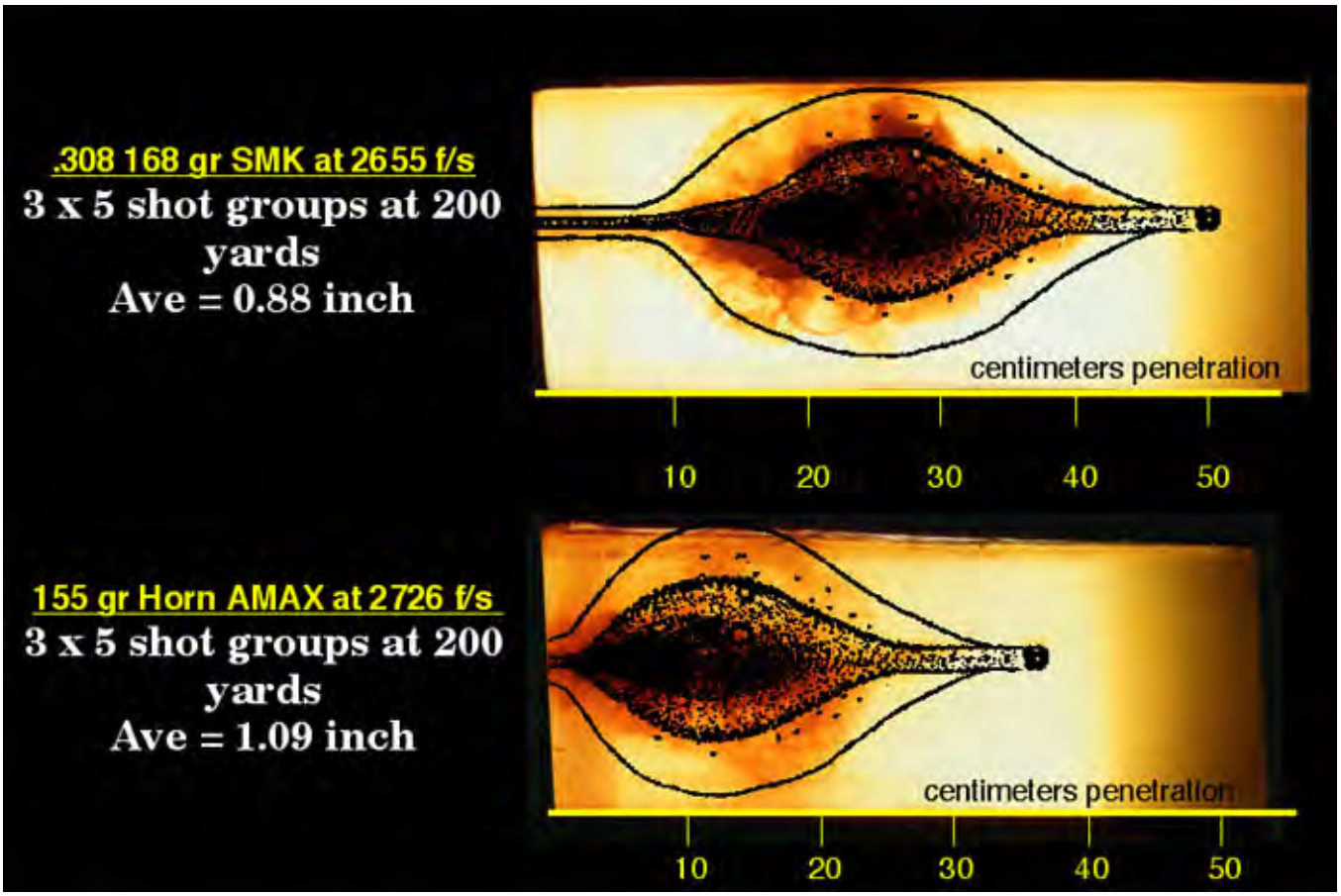


While snipers like to talk of head shots, there are an inordinate number of torso hits in the law enforcement forensic literature. As posted above, ASA indicates 47% of sniper shots were to the head (104/219), while 53% were to the body (115/219). As a result, law enforcement sniper bullets need to exhibit terminal performance which can consistently induce rapid incapacitation with shots to the torso, as well as the head. If you use a 5.56 mm, what happens when if you have to shoot through a window or into a vehicle, how about if the bad guy has something over his chest--perhaps AK mags? 5.56 mm is suddenly not looking so good. Superior terminal effects and barrier penetration ability are why .308 dominates LE sniper use; .308 accounts for 74.5% (161/216) of sniper shots chronicled in the ASA data base. Historically U.S. law enforcement and military snipers have chosen the extremely accurate, competition proven .308 Sierra Match King OTM bullets in 168 gr (M852) or 175 gr (M118LR). Unfortunately, the SMK's have significant terminal performance problems, including very inconsistent behavior, that render them a poor choice for LE sniping. In addition, SMK's will frequently exit the target and pose a significant downrange hazard to innocent bystanders and friendly personnel. In fact, according to ASA data, 90% of SMK shots have exited the suspect and posed a downrange hazard.



As discussed by both Fackler and Haag, the cause of SMK inconsistent terminal ballistic behavior appears to be associated with the diameter of the hollow point at the tip of the Match King bullet. Match Kings produced in the 1980's had tip diameters of 0.028" to 0.038", while recent Match King tip diameters appear to range from 0.012" to 0.024". The smaller the tip diameter of the hollow point, the more the Match King tends to behave like a FMJ bullet; conversely, increasing the tip diameter enhances bullet upset in tissue. Fackler and Haag both have reported that when the SMK open tip is enlarged to at least 0.055", the Match King offers consistent expansion and fragmentation with virtually no change in accuracy.

As a result of their mission profile and typical engagement distances, military snipers are less affected by the inconsistent terminal effects of SMK's than U.S. law enforcement snipers; for military snipers, consistent exceptional long range accuracy is paramount. For law enforcement use, the inconsistent terminal effects of SMK's can have tragic human and litigious consequences. U.S. law enforcement snipers have two choices to avoid inconsistent SMK terminal performance: Demand that Sierra market specific law enforcement Match Kings with hollow point diameters of at least 0.055" or use a different bullet which offers both acceptable accuracy and more reliable terminal performance. Luckily, several bullets are available which more than meet the requirements of LE snipers, including a variety of polymer tip, JSP, and JHP projectiles. The .308 Hornady TAP loads using polymer tip AMAX bullets offer consistently superior terminal performance compared to standard SMK bullets, although the SMK's are generally a bit more accurate. Are LE snipers willing to trade a slight bit of accuracy to eliminate SMK variability & gain consistently improved terminal effects?

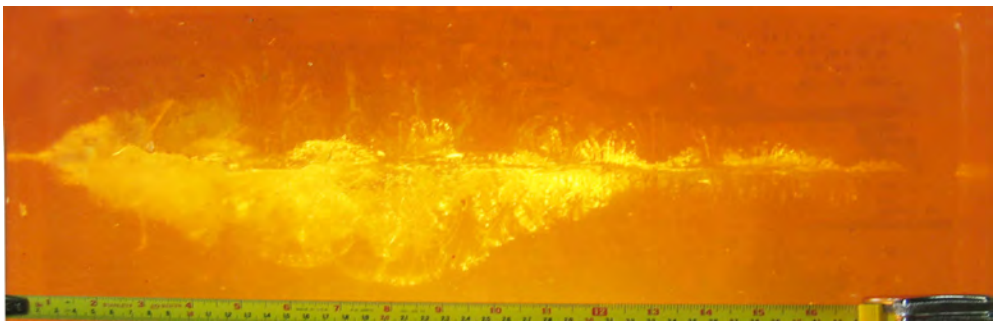


The 155 gr AMAX consistently offers nearly perfect terminal performance characteristics in unobstructed shots--ideal penetration, good fragmentation, and perfectly placed large temporary cavity. All of the .308 AMAX bullets we are aware of fired in OIS incidents to date have remained in the suspects' torsos; damage on autopsy has been quite impressive and exactly as predicted based on lab analysis. The 110 gr AMAX has a shallower penetration depth with a rounded temporary stretch cavity, while the 168 gr and 178 gr AMAX have deeper penetration than the 155 AMAX, with a more oval, narrower temporary stretch cavity. BH also loads AMAX bullets.

Loads with similar ideal wound profiles in unobstructed shots as the 155 gr AMAX include the Nosler 150 gr Ballistic Tip PT, Speer 150 Gold Dot JSP's (*and identically constructed Federal 150 Fusion JSP*), Hornady and Nosler 155 gr OTM, Federal 165 gr TRU JHP, Remington 165 gr AccuTip PT, Winchester 165 gr Ballistic Silver Tip PT, 150 & 165 gr Sierra Game Kings.

Unfortunately, intermediate barriers are a significant issue for snipers. As noted, ASA states 23% (50/219) of law enforcement sniper shots involved intermediate barriers, typically glass. Unfortunately, the SMK and other fragmenting projectiles are NOT generally good barrier rounds. As s result, an ideal LE sniper projectile needs to offer accuracy close to a SMK, consistent terminal effects similar to the AMAX, and not have the terminal performance or trajectory degraded by intermediate barriers, particularly glass.

Glass barriers are one of the most difficult challenges for LE snipers. OTM bullets like the SMK's generally exhibit unfavorable fragmentation and trajectory deviation when fired through glass intermediate barriers, resulting in degradation of terminal wounding effects. Despite gunstore commando lore to the contrary, FMJ bullet terminal performance is extremely erratic against glass. Bonded JSP/PT bullets and true AP bullets like M993 are often able to defeat glass intermediate barriers while retaining their mass, although they may exhibit very deep penetration in soft tissue and can frequently exit the suspect and pose a downrange hazard. In addition, they are not always as accurate as other bullet designs. PT bullets, like the Hornady AMAX and Nosler Ballistic Tip, offer somewhat better performance against glass than OTM bullets like the SMK, but are not the equal of barrier blind loads. The Federal Tactical load using the 165 gr Trophy Bonded Bear Claw JSP offers superb terminal performance in both unobstructed shots, as well as those through intermediate barriers; it is the most tried and tested barrier blind load, however, accuracy is typically in the 1.5-3 MOA range. Newer barrier blind loads like the BH loaded 180 gr Nosler Accubond bonded PT load and 168 gr Federal Tipped-TBBC bonded PT (*LE308TT2*) offer sub-MOA accuracy along with outstanding terminal performance in both soft tissue and glass. Because of their deep penetration characteristics, plan that barrier blind loads will likely exit the target, so be aware of the backstop.



BG: Nosler 180 gr Accubond

Currently the best .308 glass barrier loads are the Federal Tactical using the 165 gr Trophy Bonded Bear Claw JSP and 168 gr T-TBBC PT, Black Hills loaded 180 gr Nosler Accubond PT, Nosler 150 & 165 gr Partition, Remington loaded Swift Scirocco II 150 & 165 gr bonded PT, Swift A-Frame 165 gr JSP, Remington Core Lokt Ultra Bonded 150 & 180 gr JSP, Speer 150 & 168 gr Gold Dot JSP's (*and identically constructed Federal 150 & 165 gr Fusion JSP's*), Hornady Interbond PT, as well as Barnes Triple Shock & MRX; all create similar deep penetrating wound profiles. Be aware that while the Barnes all copper TSX/TTSX bullets are great projectiles and offer good penetration through barriers, when first hitting a laminated automobile windshield intermediate barrier, the TSX/TTSX bullets exhibit less expansion than other "barrier blind" loads, as the Barnes jacket either collapses at the nose, the jacket "petals" fold back against the core, or the "petals" are torn off. This phenomena has been documented by the FBI BRF, as well as being noted in our testing.

TSX left vs. Scirocco; BG top over auto windshield

- For military snipers and others needing long range accuracy, the SMK 175 gr OTM is the way to go. Another good long range choice is the 155 gr Lapua Scenar OTM.
- For unobstructed shots, the Hornady 155 TAP offers outstanding accuracy nearly on par with SMK's, as well as more consistent terminal effects, increased incapacitation potential, and better performance after penetrating through glass intermediate barriers than SMK's; as a result, the Hornady 155 gr TAP using the polymer tip AMAX bullet, along with similar performing projectiles are probably a better choice for LE snipers than SMK's.
- For intermediate barrier penetration, rounds like the Federal T-TBBC and TBBC, Hornady Interbond, Nosler Accubond & Partition, Remington Core Lokt Ultra Bonded, Swift Scirocco II, Speer Gold Dot/Federal Fusion, Barnes TTSX/TSX, as well as M993 AP are the best choices.

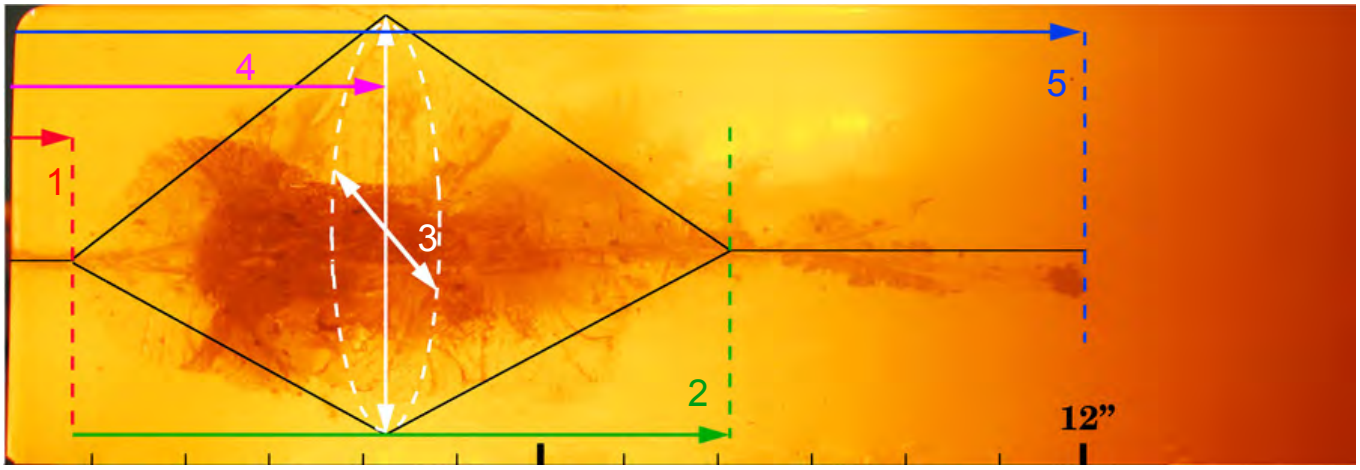
The advent of reliable, accurate, ergonomic .308 semi-auto rifles like the 16" barrel KAC SR25 ECC, LaRue OBR/PredatOBR, LMT MWS, and FN Mk17/SCAR-H allow LE snipers to retire their bolt guns in favor of these much more capable and versatile weapons systems. With properly trained shooters, appropriate optics, and good quality ammunition, these rifles are capable of effectively hitting targets from 0-800+ yards. *Note: with these new rifles, consider using faster barrel of at least 1/10 and preferably 1/8.* Some of the the characteristics of an ideal performing general purpose rifle projectile are described in commentary by SSA Buford Boone of the FBI BRF:

-- Penetration of 12 to 18 inches
-- No impact AOA induced variations
-- Blind to barriers
-- No deviation from shot line after impact
-- Minimal fragmentation
-- Consistent terminal performance from 0 – 300 meters
-- Sufficient accuracy to hit threat targets out to 600 meters

The current .308 rifle loads that best meet these requirements when fired from a 16" barrel semi-auto, include the Remington 150 gr Core-Lokt Ultra Bond JSP, followed by the Speer 150 gr Gold Dot JSP, and Swift 150 gr Scirocco bonded PT.

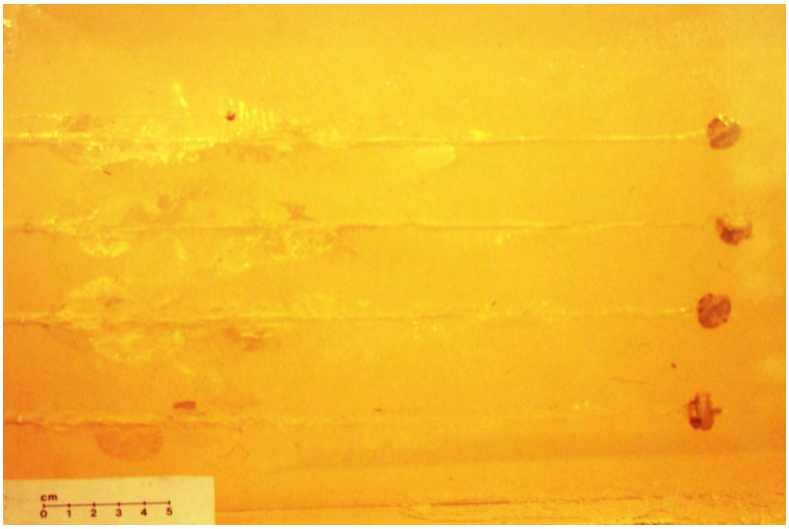
LE agency procurement programs frequently have difficulty interpreting and assessing gelatin test shots. *Note that "Barrier Blind" ammunition should demonstrate minimal changes in terminal performance between unobstructed shots into bare gelatin and those obstructed by intermediate barriers.* Below is an ideal rifle wound profile and gel test interpretation guidelines.

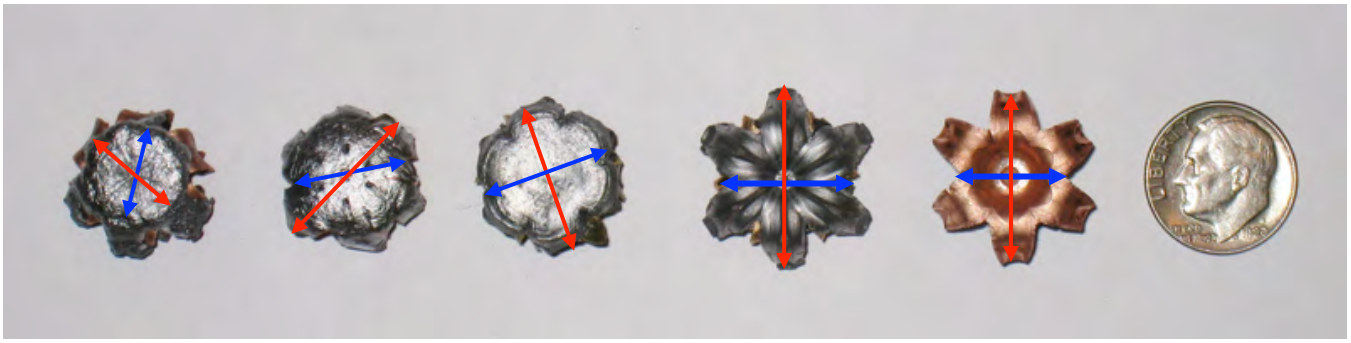
1. NL = Initial Upset Depth (Neck Length) -- *Optimally 1" or less, up to 3"*
2. TCL = Temporary Cavity Length -- *As long as possible in the first 12" of penetration*
3. TC = Temporary Cavity Height & Width -- *Bigger is better in first 12" of penetration*
4. TCD = Depth to Max Temp Cavity Diameter -- *Typically at 4" to 6" of pen*
5. PEN = Total Depth of Penetration – *Less than 12" and more than 18" is not ideal.*



Pen = 12.1" NL = 0.8" TC = 4.5" max diam @ 4.2" depth TC length from 0.8" to 8.1"

Since common service handgun calibers do not create a TC of any significance, handgun caliber gel testing analysis focuses on measuring the penetration depth, as well as diameter and weight of the recovered projectiles. Note that the correct RD of each bullet is calculated by averaging the largest and smallest diameters measured at the leading edge of the deformed bullet.





Note that all of the recovered projectiles above demonstrate exactly the same ave RD (0.64")

Author's Background & Qualifications

Dr. Roberts is currently on staff at Stanford University Medical Center; this is a large teaching hospital and Level I Trauma center were he performs hospital dentistry and surgery. After completing his residency at Navy Hospital Oakland in 1989 while on active military duty, he studied at the Army Wound Ballistic Research Laboratory at the Letterman Army Institute of Research and became one of the first members of the International Wound Ballistic Association. Since then, he has been tasked with performing military, law enforcement, and privately funded independent wound ballistic testing and analysis. As a U.S. Navy Reserve officer from 1986 to 2008, he served on the Joint Service Wound Ballistic IPT, as well as being a consultant to the Joint FBI-USMC munitions testing program and the TSWG MURG program. He is frequently asked to provide wound ballistic technical assistance to numerous U.S. and allied SOF units and organizations, such as the Canadian Armed Forces Weapons Effect and Protection SIPES TDP. In addition, he has been a technical advisor to the Association of Firearms and Toolmark Examiners, as well as to a variety of Federal, State, and municipal law enforcement agencies. He has been a sworn Reserve Police Officer in the San Francisco Bay Area, where he now he serves in an LE training role.