Fullbore Bullet Update: 2009

By: Bryan Litz

There have been several interesting developments of Fullbore bullets in the recent past (.308 caliber bullets that weigh less than 156 grains intended for International Fullbore and Palma shooting). This article will take a look at the new offerings from Sierra and Berger as well as some options available in continents other than North America.

The Design of Fullbore Bullets

The design of bullets intended for Fullbore competition is quite limited in most regards. The caliber of the bullet is fixed to .308" and the weight is restricted to less than 156 grains. Since the cartridge is also dictated by the rules of the contest (.308 Winchester), the muzzle velocities that can be achieved are limited to a maximum of around 3000 fps. Apparently the only thing that really distinguishes the ballistic performance of the various Fullbore bullets is their profile, which determines aerodynamic drag. *The efficiency with which the bullet's ogive parts the air to make way for the bullet, and the effectiveness of the boat tail at reducing base drag are the only design factors that really set the modern Fullbore bullets apart*.

Inherent precision (usually referred to as *accuracy*) is another extremely important attribute that will determine your success with a particular bullet. The inherent precision is mostly dictated by the quality of manufacturing. In modern times, the precision level for the various brands of bullets is really quite good and the biggest difference among them is their ballistic performance, which comes down to design. This article will not address the inherent precision of the bullets being considered, only the ballistic performance.

Assessing Ballistic Performance

The first and most important step in any performance analysis is to decide what measure of merit you care about. In the case of Fullbore bullets, it's wind deflection. Assuming the bullets are well made and capable of precision (which is a safe bet with most modern match bullets), the bullet with the least wind deflection will make the wind readers job easier, and tend to produce the highest scores.

As mentioned above, the only difference among the various Fullbore bullets is their shape, since the caliber and weight are fixed. It's pretty simple: *the 155 grain .30 caliber bullet with the lowest drag profile will have the highest Ballistic Coefficient (BC) and the least amount of wind deflection from a given muzzle velocity.*

In order to calculate the bullet's wind deflection, you need to know its BC and muzzle velocity. We can assume that all the Fullbore bullets are capable of around 3000 fps muzzle velocity and that any difference in ballistic performance is due to the bullet's BC. To perform a meaningful analysis, you need accurate information. The BC's advertised by the bullet makers have always been in question due to the different methods of determining them, and the fact that they're sometimes used as marketing points. In order to have a fair performance comparison, BC's should be measured with a common method that's repeatable, and allows for a meaningful comparison. The performance data presented in this article is what I've measured for each bullet, using the velocity and time of flight measurement technique described in **[REF1]**. It should be noted that my method of BC measurement is repeatable within +/- 1% and produces results that are in agreement with several other published and credible sources including **[REF2], [REF3], [REF4]**.

For modern long range bullets with long noses and boat tails, the G1 standard projectile is not the proper standard to use for defining BC. Rather, the G7 standard projectile is a much better match. Defining BC's in reference to the G7 standard results in BC's that are much less sensitive to velocity than the classic G1 standard. For example, the 155 grain Berger VLD has a G1 BC that varies from 0.465 (@3000 fps) down to 0.402 (@1500 fps), which is a 14% variance. However, if you define the BC of that same bullet based on the G7 standard, the G7 BC goes from 0.228 (@3000 fps) down to 0.223 (@1500 fps), which is less than a 3% variation. Clearly there will be less error introduced into ballistic calculations by using the G7 BC's, so they will be used to generate all of the following ballistic performance data. Average G1 BC's will be given in gray as a reference.

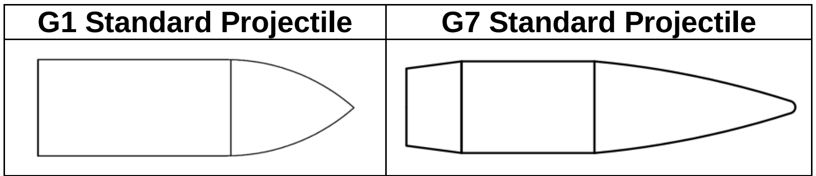


Figure 1. The drastic difference in the projectile shapes is why G1 BC's vary so much with velocity. The G7 standard is a good match for long range bullets, so G7 BC's don't vary nearly as much with velocity.

The bullets

The bullets presented here are all of the Fullbore bullets that were available to me for testing. Exclusion of any particular bullet is not intentional. The bullets are listed from top to bottom, in order of decreasing BC.

Scale profiles are provided which show the relative shape and proportions of the bullets. Remember that the bullet's external profile is the only thing that separates them from each other. Notice that the bullets at the top of the list are longer, in particular they have longer noses than the bullets near the bottom of the stack. Nose length is a very important factor in drag reduction.

The sectional density (SD) is given for each bullet, and is the same for all the bullets shown except for the 155.5 grain Berger FULLBORE bullet. Sectional density is the bullets weight (in pounds) divided by its caliber squared. For example, the SD of a 155 grain .308 caliber bullet is: $(155/7000)/0.308^2 = 0.233$ lb/in^2. (Divide grains by 7000 to get pounds) The SD of the 155.5 grain bullet is 0.234 lb/in^2 because it's 0.5 grains heavier.

The next metric in the chart is the bullet's form factor, i_7, referenced to the G7 standard. The form factor is the ratio of drag for the bullet compared to the standard bullet. When we say the BC is referenced to the G7 standard, what we mean is that the form factor (shape factor) is referenced to the G7 standard. If a bullet shape has less drag than the G7 standard projectile, then the form factor, i_7, is less than 1.0. On the other hand, if the bullet has more drag than the G7 standard projectile, then the form factor is greater than 1.0. G7 form factors of less than 1.0 are quite rare for Fullbore bullets, and there were only 3 bullets tested that exhibited such low drag.

Modern Fullbore bullets

Berger 155.5, Lapua 155 Scenar, HBC BJD, New Sierra, Berger VLD, PMP, Old Sierra, Hornady

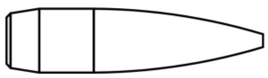
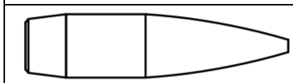
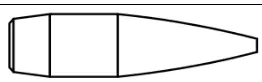
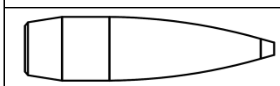
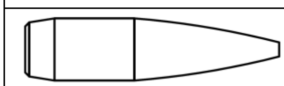
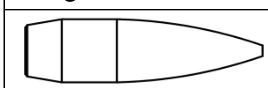
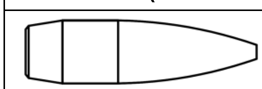
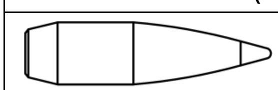
Bullet	SD	i_7	G7 BC	G1 BC	Wind Deflection*	Retained Velocity**
 *Berger 155.5 Fullbore*	0.234	0.988	**0.237**	0.464	91.0”	1304 fps
 *Lapua 155 Scenar*	0.233	0.988	**0.236**	0.462	91.6”	1299 fps
 *155 HBC BJD (Australia)*	0.233	0.989	**0.236**	0.462	91.6”	1299 fps
 *Sierra 155 Palma (2156)*	0.233	1.018	**0.229**	0.447	95.9”	1258 fps
 *Berger 155 VLD*	0.233	1.039	**0.225**	0.439	98.5”	1234 fps
 *155 PMP (South Africa)*	0.233	1.041	**0.224**	0.439	99.2”	1228 fps
 *Sierra 155 Palma (2155)*	0.233	1.092	**0.214**	0.417	106.7”	1165 fps
 *Hornady 155 Amax*	0.233	1.100	**0.212**	0.415	108.3”	1152 fps

Figure 2. Ballistic performance comparison for 8 Fullbore bullets.
***Wind deflection is for a 10 mph crosswind at 1000 yards**
****Retained velocity is at 1000 yards. Both wind deflection and retained velocity assume 3000 fps muzzle velocity and standard sea level atmospheric conditions.**

The next item listed is the bullets G7 BC. This is simply the bullets sectional density (SD) divided by the G7 form factor. If a bullet has a form factor that's less than 1.0, then its BC will be greater than its sectional density, and vice-versa. The G7 BC's are average values from 3000 fps to 1500 fps, and there's very little variance.

The G1 BC's are given only as a point of reference. The G1 BC's are also averaged from 3000 fps to 1500 fps, but they vary a lot more with velocity than the G7 BC's.

The performance metrics to the right of the double line are wind deflection for a 10 mph crosswind at 1000 yards, and remaining velocity at 1000 yards. Both metrics assume 3000 fps muzzle velocity and standard sea level conditions.

Last year I presented results for 3 of the above bullets. Due to the ongoing, repeat testing, the assessments have been adjusted slightly. The chart above is the cumulative assessment of these bullets based on multiple tests done to date, as of April, 2009. The G7 BC's that are different from last year's assessments (**[REF1], [REF5]** and **[REF6]**) are:

The Berger 155 VLD lowered from 0.228 to 0.225 (-1.3%)

The Sierra 155 (2155) Palma increased from 0.213 to 0.214 (+0.5%)

The Lapua 155 Scenar increased from 0.234 to 0.236 (+0.8%)

Although testing the bullets on multiple occasions produces slightly different BC's, the running average is a more reliable number because it's based on more measurements. The updates are relatively minor, and don't result in major impacts to the performance analysis.

The top 3 bullets tested are the Berger 155.5 FULLBORE, the Lapua 155 Scenar, and the 155 grain HBC (of Australian origin). These 3 bullets have practically identical BC's, certainly within the measurement uncertainty of my testing.

The Berger FULLBORE bullet is an extremely inherently accurate bullet. It was used to win the 2008 US Palma Individual Trophy at Camp Perry (450-26X) as well as set the midrange (iron) National Record of 450-39X. Berger's advertised BC's are the same as in the chart above.

The great ballistic performance of the 155 Lapua Scenar is no secret to many shooters. It's been pretty far ahead of the rest until only recently when some of the newer offerings have become available from other companies. Lapua advertises a G1 BC of 0.508 for this bullet. My measured G1 value at 3000 fps was 0.497 which is only a 2% difference at high speed, but the *average* BC of this bullet over 1000 yards is 0.462; much lower than the advertised *high speed* BC.

The Australian HBC BJD bullet was a surprise (for me). A friend sent me some from down under to test out of mutual curiosity. The bullets have an aggressive secant ogive and a long 7 degree boat tail which is a splendid combination that results in very low drag. To my knowledge, there is no BC advertised for this bullet, but my measurements indicate that it's among the best ballistic performers in its class. *HBC* stands for *High BC,* and *BJD* stands for Bob and Jan Dyer who make the projectiles. Bob and Jan's company is "R & J Sportsgoods" which is based in Darwin and the projectile is available through all State and Territory rifle association's within Australia. Those interested can find an appropriate contact thru Australia's NRA: http://nraa.com.au/members/members.html

A commonly used performance measure is *wind deflection in a 10 mph crosswind at 1000 yards.* For the top 3 bullets, the wind deflection is predicted to be 91.0", 91.6", and 91.6" respectively, which is practically identical ballistic performance. They reach 1000 yards with a very healthy ~1300 fps remaining in standard atmospheric conditions, assuming 3000 fps muzzle velocity.

Next on the list is the new Sierra Palma bullet (2156) which has a very much improved BC over their old Palma bullet (2155). The new Palma bullet has only been out a short time, but has already proven itself in international competition. In September 2007, the US Rifle Team used this bullet to win the Spirit Of America International Fullbore Rifle Match at the NRA Whittington Center in Raton, NM. The bullet was so new that they were delivered directly to the range, and the coaches swapped out the bullets from the ammo that the shooters brought to the match! The winning result is a testament not only to the bullet's very capable ballistic performance, but also to its inherent accuracy in so many rifles with no load development. Note that my average measured G1 BC for this bullet is 0.447, and the average of Sierra's advertised values is 0.446, which is practically identical.

The Berger 155 VLD is next on the list. Once Berger's best Palma bullet, this design now represents just another option since the introduction of the superior 155.5 grain FULLBORE bullet. Note that the Berger VLD is the only bullet on the list of Fullbore bullets that is also classified as a hunting bullet.

The 155 grain *PMP* bullets are made in South Africa, and were provided to me for testing by another good friend. PMP stands for *Pertoria Metal Processing*, and the samples I tested were from lot# 66. The bullets seem very similar in dimensions to the old Sierra Palma bullet (2155) with the exception of the very small meplat (tip) diameter. The meplat's on the samples I tested measured only 0.052" in diameter which is extremely small for a factory (un-pointed) bullet. I'm not aware of the advertised BC of these bullets, but their measured BC is where it's expected to be according to the bullet's shape.

The old Sierra Palma bullet, which saw heavy use in international competition by many countries, now finds itself near the bottom of the list of ballistic performance. A very inherently accurate bullet and a very good option for short and midrange matches, this bullet simply lacks the design to compete with the superior ballistic performance of the more modern offerings at long range.

The Hornady 155 Amax comes in just below the old Sierra. The plastic tips insure very consistent BC's, but are not sharp enough to make up for the other areas where this bullet finds its design lacking. The short boat tail is too steep at 13+ degrees to achieve significant base drag reduction and the ogive is very short. The combination results in over 108" of wind deflection and the bullet barely remains supersonic at 1000 yards. If Hornady wants to offer a better Fullbore bullet, they'll have to turn to a design that's more like their outstanding 208 grain Amax which has a longer shallower boat tail, and a longer ogive for drag reduction.

Analysis

So now that the raw results (BC's) have been presented, how do we know what to make of it? The sterile *wind deflection in a constant 10 mph crosswind* performance metric is kind of useful, but what does it mean in terms of points in a match? Is there a real, practical difference between 91.6” vs 95.8” of wind deflection, or is a difference that small just lost in the noise?

To attempt to shed some light on this question, I’ll turn to modeling and simulation. The results of a model are only as accurate as their inputs. The bullet performance can be modeled accurately, but how do you model a shooter, and the effects of bullet performance on score? The way I’ve chosen to approach this is statistically. A ballistics program was *looped* to run for 20 shots. On each shot a different wind uncertainty is applied to model the effect of an imperfect wind judgment by the shooter or coach. The idea is that the better performing bullets should result in fewer lost points because they’re deflected less by a given wind. Running this simulation multiple times can reveal how much difference a certain performance advantage can make to a shooter’s score.

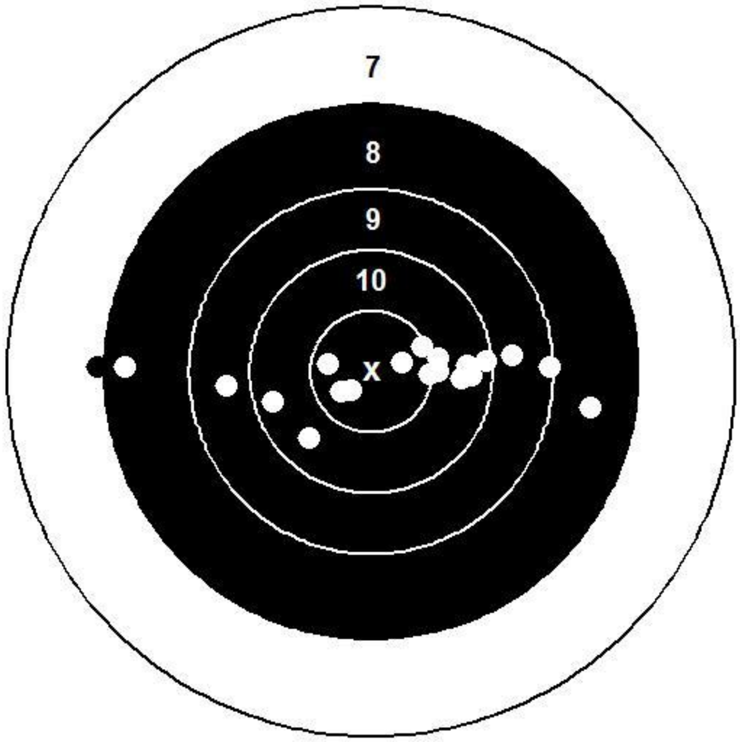
The shooter will be modeled as being capable of holding *X-ring* elevation. (Specifically, the standard deviation of the shooters grouping ability is 2.5”. +/- 2 standard deviations is +/- 5”, and represents the 95% confidence interval for a normal distribution.)

For the purposes of generating equal conditions for the various bullets, a crosswind uncertainty of +/- 2 mph is applied. (Specifically, the standard deviation of the shooters/coach’s ability to call wind is 1 mph.) In other words, the crosswind uncertainty is modeled to be less than 2 mph for 19/20 shots.

The following figure shows a visual representation of one of the groups under the defined conditions and uncertainties. The numeric values given for each case show the min score, max score, and average score that was simulated for each bullet over the course of 100 simulated matches.

Some of the interesting things to note about Figure 3 are related to the statistical nature of the simulation. For example, notice that the high score shot with the new Sierra and the Berger VLD is 1 point higher than the high score shot with the slightly higher BC bullets at the top of the list. This goes to show that over the course of 100 matches, it’s possible to shoot a higher score with a slightly inferior bullet because of the statistical nature of error.

Results of Simulated 20 shot matches



This is an example target showing the horizontal stringing of shots

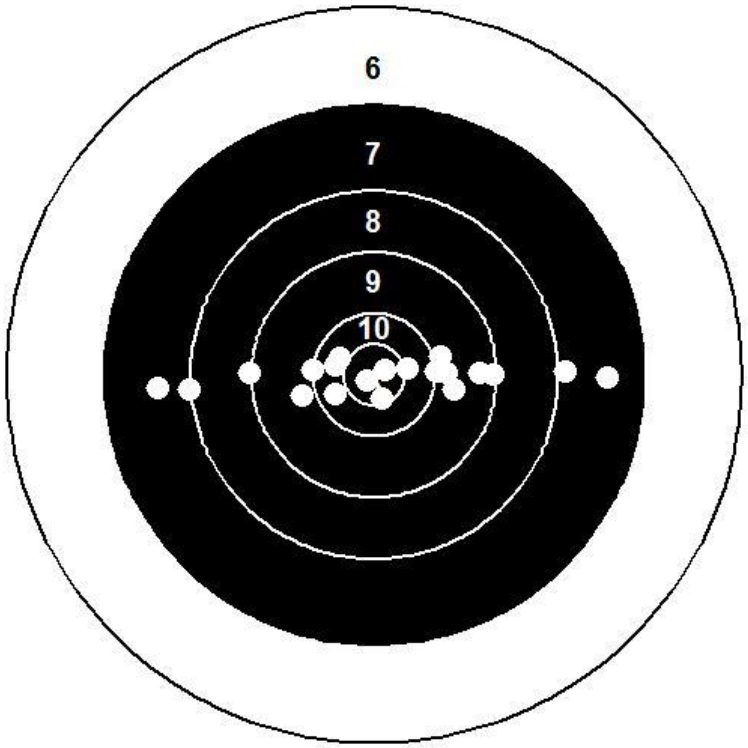
Bullet	G7 BC	High	Low	Average
Berger 155.5, Lapua Scenar, HBC	0.236	197	183	192-8X
New Sierra (2156)	0.229	198	183	191-7X
Berger 155 VLD	0.225	198	181	190-7X
PMP (Africa)	0.224	197	182	191-7X
Old Sierra (2155)	0.214	195	179	188-7X
Hornady Amax	0.212	196	179	188-7X

Figure 3. Simulated scores based on +/- 2 mph of crosswind uncertainty.

Also note that the average score goes from 192, down to 191, then to 190, back up to 191. This is another symptom of the statistical nature of uncertainties in shooting. *Having a slight advantage in BC does not guarantee a superior score!* Just look at the range from high to low score for any given bullet; there's more than 10 points difference for a given bullet in any given match yet the difference between the *best* and *worst* ballistic performers is only 4 points. The take away from this exercise is that although the higher BC bullets do stand to yield slightly higher scores on average, the fact remains that all the bullets are .30 caliber, 155 grains, and leaving the muzzle around 3000 fps. These facts dictate the majority of the bullets ballistic performance. The difference in BC that's caused by profiling the bullet to achieve lower drag and higher BC's is worthwhile, real, and will yield benefits in the long run, but it doesn't turn night to day.

A final thought regarding the modeling and scores: if the wind uncertainty were modeled as +/- 1.5 mph instead of +/- 2.0 mph, the average score for *each bullet* goes up a solid 4 points. In other words, if the shooter or coach can refine their ability to judge crosswind by only 0.5 mph (from +/- 2.0 mph to +/- 1.5 mph) that makes as much difference in average score as going from the lowest BC bullet to the highest.

Results of Simulated 20 shot matches



This is an example target showing the horizontal stringing of shots

Bullet	G7 BC	High	Low	Average
Berger 155.5, Lapua Scenar, HBC	0.236	190	167	180-4X
New Sierra (2156)	0.229	193	164	179-4X
Berger 155 VLD	0.225	189	164	177-4X
PMP (Africa)	0.224	189	161	177-4X
Old Sierra (2155)	0.214	189	159	176-3X
Hornady Amax	0.212	188	154	175-3X

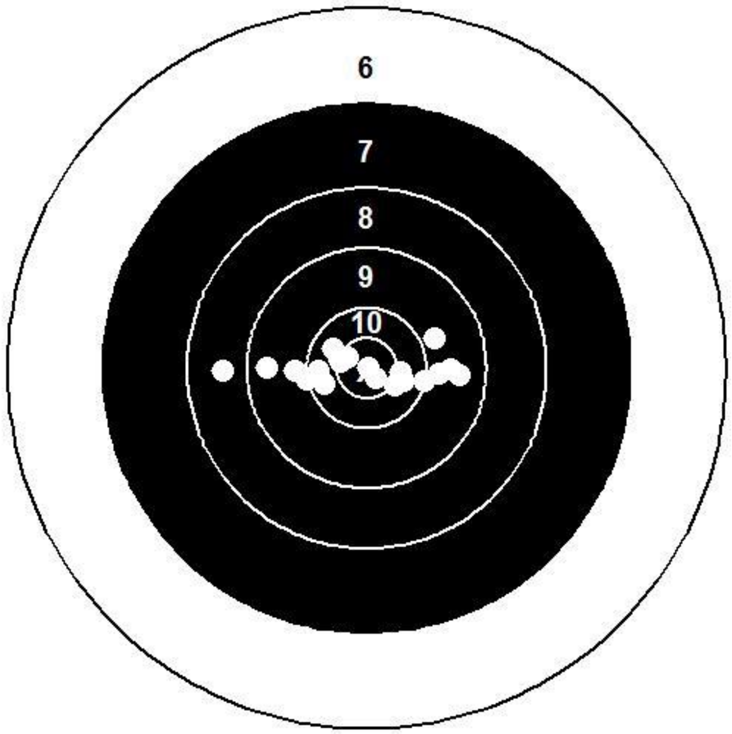
Figure 4. Simulated scores based on +/- 2 mph of crosswind uncertainty.

Of course overall performance is maximized by optimizing each component in the system; meaning that the best approach is to shoot high BC bullets *and* work on improving your wind reading skills. As with many endeavors, striving for balance is key. Success is achieved when you take a well rounded approach, with a true understanding of the relative importance of each factor, not by considering one element or another to be *all important* to the exclusion of the others.

What About F-class?

The above Fullbore bullet analysis was geared specifically for the NRA LR prone target with a 10" X-ring, 20" 10 ring, etc. The F-class target has smaller inner rings. It's obvious that the smaller rings are more sensitive to small errors than the larger rings of the prone target. For example, a shot that's a solid 10 on the prone target may be a 9 on the F-class target. So the question is; *how much more sensitive is the F-class target to a difference in ballistic performance compared to the prone target?* Common sense suggests that you should be able to resolve a bigger advantage in score for a given ballistic performance advantage, but how much? Again I'll turn to the modeling.

Results of Simulated 20 shot matches



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Berger 155.5, Lapua Scenar, HBC	0.236	198	188	194-8X
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Berger 155 VLD	0.225	199	185	193-7X
PMP (Africa)	0.224	198	185	192-7X
Old Sierra (2155)	0.214	198	182	191-7X
Hornady Amax	0.212	196	184	190-7X

Figure 5. Simulated scores based on +/- 1 mph of crosswind uncertainty.

For this simulation, we'll consider the shooter/coach to have the same wind reading ability as the prone scenario (95% of crosswind calls are within +/- 2 mph), but we'll tighten up the precision a bit for the F-class shooter. We'll assume the shooter and their equipment is capable of ~5" groups, which is extremely good.

The results in Figure 4 show the same information as Figure 3 had for the prone target. The first thing to notice is that the average score is about 12 points lower. This is completely expected. What may come as a surprise is that *the advantage of the higher BC bullets isn't much more profound than it was for the prone target.* On the prone target, there was only 4 points separating the average score for the worst BC to the best BC. On the F-class target, 5 points separate the best from the worst.

Why is that? Well, think about how a target works. It measures accuracy using scoring rings. Increasing the number of rings on a target increases the targets ability to resolve a difference in accuracy / ballistic performance. To look at it another way, an accuracy improvement is more likely to *register* on a target with more rings because the area of the target is broken up into finer segments. The fact is that the F-class target only has 1 more ring than the prone target, so it's not really much better at resolving differences in accuracy outside where the additional ring is (beyond 10" from center). Beyond the 20" circle, the rings are the same size, they're just worth 1 less point. That's why the average score goes down so much, but the range of scores is similar.

Of course this result/conclusion is specific to the simulation parameters. The variables that were chosen resulted in shots being scattered all across the target face, and the small effect of the additional inner ring wasn't very important. What would happen if the simulation were re-run with less wind uncertainty? If the shots were only scattered from 9 ring to 9 ring instead of out to the 7 ring, would the smaller inner rings be more important? Figure 5 contains the results of the F-class simulation being run for ½ of the original wind uncertainty (+/- 1 mph of wind uncertainty rather than +/- 2 mph).

As you can see in Figure 5, the average scores are all higher; a result of less wind uncertainty. However, the relative advantage of the higher BC bullets is still far from a landslide. In fact, the difference is still only 4 points from best to worst.

This final analysis re-enforces that superior ballistic performance is helpful, and will result in higher average scores in the long run, but the difference between the highest BC option and a mediocre BC is certainly not a decisive element by itself, regardless of how difficult the conditions are.

Fullbore Bullets in Service Rifles

For those who choose to use 155 grain bullets in one of the .30 caliber service rifles, one of the big concerns is remaining supersonic at 1000 yards. The shorter barrels and reduced chamber pressures that the service rifles are capable of means they're working with reduced muzzle velocities, and often times the bullets can't remain supersonic all the way to 1000 yards. Some bullets don't suffer terribly from this, while others can completely lose stability. It's not possible to predict how the different bullets will react to transonic speed, so a good policy is to try to stay above the speed of sound (~1120 fps) and avoid the potential problem.

30 cal Service Rifle: Retained Velocity			
Bullet		**Sea Level**	**3000 ft ASL**
	Muzzle	**1000 yards**	**1000 yards**
Berger 155.5, Lapua Scenar, HBC	2741 fps	1134 fps	1246 fps
New Sierra (2156)	2741 fps	1100 fps	1209 fps
Berger 155 VLD	2741 fps	1084 fps	1188 fps
PMP (Africa)	2741 fps	1081 fps	1183 fps
Old Sierra (2155)	2741 fps	1050 fps	1127 fps
Hornady Amax	2741 fps	1044 fps	1117 fps

Table 1. Retained velocity at 1000 yards

The 30 caliber service

rifles have barrel lengths that go from 24" (M1) to 22" (M14/M1A) down to 20" (M110). A nominal muzzle velocity that can be expected from one of these service rifles with a 155 grain bullet is around 2740 fps. At this muzzle velocity, some of the bullets will have a very hard time remaining supersonic. Table 1 shows the remaining velocity of each bullet at 1000 yards, assuming 2740 fps muzzle velocity. Retained velocity is shown for standard sea level conditions and for standard conditions at 3000 feet above sea level. Note that at sea level, 95 degrees F, 100% humidity, the air density is the same as the *standard* air density at 3000 ft. In other words, on a *typical* summer day at Camp Perry (95 deg, 100% humidity, sea level), you can expect the retained velocities in the 3000 ft ASL column.

Notice that in standard sea level conditions, only the 3 highest BC Fullbore bullets reach 1000 yards with (barely) supersonic velocity from the service rifle. All others fall short. However, if you go up in altitude or it's just hotter at sea level, then all of the bullets can make it to 1000 yards with supersonic speed. All of the velocities in Table 1 were calculated using the G7 BC's. Using G1 BC's to calculate remaining velocity for modern long range bullets will result in a significant *over-estimation* of retained velocity.

Stability for Modern Palma Bullets

The accepted standard barrel twist rate for Palma/Fullbore rifles has been 1:13" for decades. Do these new, longer bullets require more twist for good stability? The short answer is no. The old (shorter) bullets could get away with 1:14" twists in most conditions, but the new longer bullets require every bit of the 1:13" twist. In fact the longest bullet is the Lapua Scenar, and according to stability predictions, it wouldn't hurt to use a 1:12" or 1:12.5", though it does work successfully in most conditions from a 1:13".

As with most well made modern bullets, it wouldn't hurt to shoot these Fullbore bullets from barrels having faster than 1:13" twists. There are many examples of shooters achieving success with 1:10", 1:11", and 1:12" twist barrels. Using faster twist barrels like this gives you the option of using heavier bullets in contests that aren't limited by a bullet weight limit.

Conclusions

We've taken a look at the Fullbore bullets from the major brands as well as a couple options that are less well known (in North America at least). There appears to be a significant range of ballistic performance (BC's). However, that apparent separation of ballistic performance is not as decisive as it may seem. According to the simulation, the highest BC bullets are only good for a small increase in average score, leaving the shooter/coach to bear the burden of wind reading. The purpose of placing restrictions on Fullbore equipment is to put shooters on an even playing field so that the best shooter/team wins as opposed to a contest of superior ballistics. Despite the existing range of ballistic performance in the various bullets that are eligible for International Palma and Fullbore competition, the basic spirit of the contest is still very much intact.

It was interesting to see that the F-class target was not able to resolve the ballistic performance advantage any better than the 'big ringed' Prone target. Average scores were much lower on the F-class target, but the *point spread* was not much different. This observation holds for easy conditions as well as difficult conditions.

.30 caliber service rifle shooters may care about the ballistic performance of the various 155 grain bullets from a retained velocity point of view. There may be an important benefit of selecting the highest BC bullets for this reason. The benefit may not be directly related to wind deflection, but remaining supersonic may be more important.

Finally, stability requirements were reviewed for the longer generation of Palma bullets. The old stand-by 1:13" twist is sufficient, although you may enjoy better selection among the heavier bullets if you choose a faster twist.

References:

1. "Ballistic Coefficient Testing of the Berger .308 155 Grain VLD" By Bryan Litz *Precision Shooting, March 2008*
2. Lapua Bullets: http://www.lapua.com/
3. Sierra Bullets: http://www.sierrabullets.com/
4. "Comparison of the Latest Berger and Sierra 155 Grain .308 Match Bullets to the 155 Scenar – Real World Results" By Kris Desrochers *Precision Shooting, April 2009*
5. "Ballistic Coefficient Testing of the Sierra .308 155 Grain Match King Palma Bullet" By Bryan Litz *Precision Shooting, April 2008*
6. "Ballistic Coefficient Testing of the Lapua .308 155 Grain Scenar" By Bryan Litz *Precision Shooting, May 2008*