APPLIED BALLISTICS ™

Introduction to Extreme Long Range (ELR) Shooting

By Bryan Litz, Applied Ballistics

Introduction

Accuracy and precision minded rifle shooters are continuously pushing the limits of long range rifle shooting. Those at the pinnacle of the sport, who routinely score first round hits on steel targets beyond a mile are calling their pursuit Extreme Long Range Shooting – ELR.

This article explores the fascinating world of ELR shooting including the special equipment, knowledge and skills required to succeed.

The Applied Ballistics ELR Team at the 2016 King of 2 Mile event. Left to right: Bryan Litz, Paul Philips, Mitch Fitzpatrick and Kelly McMillan. The rifle is Mitch's self built 375 Lethal Magnum that he used to win the event.

What is ELR?

As stated in the introduction, ELR stands for Extreme Long Range, but what is that, in numbers? ELR may mean something different for a .308 Winchester shooter as compared to a .50 BMG shooter. Where is the threshold between normal long range and Extreme Long Range generally considered to be?

The fact is that range becomes *extremely long* at different distances depending on the performance of the rifle you're shooting. One way of accounting for this is to consider ELR shooting to be the distance at which your bullets slow to transonic speed. All high performance centerfire bullets start out somewhere around Mach 2 or 3, which is 2 or 3 times the speed of sound. As the bullets fly downrange the loose speed due to aerodynamic drag. The bullets trajectory remains somewhat predictable up until the part when the bullet slows to around Mach

1. The range of flight speeds from Mach 1.2 down to Mach 0.8 is known as the *transonic range* of flight. It becomes very difficult to predict trajectories for spin stabilized bullets flying in the transonic zone which occurs at a different range for different cartridges. High performance cartridges can remain supersonic out to 1500, 2000 yards or more whereas some lower performance rounds won't make it 1000 yards. Based on this performance metric of the bullet flying in the transonic zone, I've suggested a possible definition for ELR shooting as: *Shooting beyond the supersonic range of your particular rifle system.* Although this definition is good in the sense that it connects to the performance of any rifle, it fails to provide an easy, simple answer to the question: *what is ELR?* Based on this definition, ELR is somewhere between 700 yards and 2700 yards, depending on rifle system and atmospherics.

In polling many ELR shooters from around the world who engage the sport in various ways, there is a general consensus that ELR is in the neighborhood of 1200 yards to one mile (1760 yards) and past, with 1500 yards being a good middle ground that most can accept as ELR distance. At 1500 yards, most normal rifle/cartridge/bullet combinations of .30 caliber and under are all transonic or very close at 1500 yards. To remain supersonic to ranges substantially past 1500 yards requires a larger caliber like .338 or .375 caliber which are both very common in modern ELR events, but we're getting ahead of ourselves. *For our purposes, we'll consider ranges of 1500 yards and greater to be what defines ELR*.

What's so hard about ELR?

A little bit of a provocative title, but the question is important! What *specifically* makes ELR more difficult? The shear distance is one of the challenges for sure but where exactly do the physics break down?

Sighting/aiming

One of the first limitations a shooter will encounter while extending his range is the limitation of elevation adjustment available in modern rifle scopes. A scope with 100 MOA or 120 MOS is more than enough when shooting out to 1000 yards, but double the range and you'll quickly find yourself running out of 'up' elevation to dial on your turret! This is one of the basic and unique challenges of ELR shooting. What to do?

- The first and most basic thing is to select a tapered scope base that allows you to zero your rifle near the bottom of it's elevation range. So if your scope has 100 MOA of internal adjustment (for example), and you mount it on a flat rail and zero at 100 yards, you'll only have about 50 MOA of available travel to 'dial up'. But if you use a scope rail that's tapered with, for example, 40 MOA, then your 100 yard zero will be 40 MOA below center, or 10 MOA from the very bottom. This gives you a total of 90 MOA of available adjustment to come up. So this simple inexpensive step nearly doubles your available elevation. Tapered scope rails are common in most all long range shooting and is basically all you have to do to get out to 1500 yards for many rifles but to go much further, you'll need additional options.
- Holding reticle. Some long range shooters chose to hold their elevation and windage with a holding reticle such as the TREMOR or MIL DOT scopes. You can use these kinds of

reticles to hold additional elevation beyond the internal range of adjustment. Typically you'll have at least 20-80 MOA available to hold in your reticle depending on magnification and weather the scope is first or second focal plane. With second focal plane scopes the reticle is only 'true' at one magnification. You can get effectively more hold in a second focal plane scope if you dial the power down. For example, if the reticle is 'true' at 22 power and you dial it down to 11 power, your hashmarks will be worth double. If you then dial down to 5.5 power, the hashmarks should be 4 times what they read (so 20 MOA in the reticle is actually 80 MOA at low power). Typically a combination of dialing and holding will get most shooters with high performance systems enough elevation to get out to around 2 miles, more or less.

Tall Target used to verify scope tracking at 100 yards.

- If you're shooting to such extreme range that you have so much bullet drop you can't compensate with a combination of internal adjustment and a reticle hold, then you have a problem! You have to aim so high, that you literally cannot see your target thru the scope. One of the most natural steps to take from here is a scope rail with a greater angle of taper. Rather than a 40 MOA rail, you could use an 80 MOA rail which means you would have +40 more MOA compared to your 40 MOA rail, but this causes a problem; if your rail taper angle is more than ½ the internal adjustment of your scope, you lose the ability to zero your rifle at 100 yards. With such a steep rail, you'll dial all the way to the bottom of your scope and your shots will still go over your target at 100 yards. For some dedicated ELR rifles, this is a sacrifice that gets made. For others who care a lot about preserving the practical function of the rifle, it's not an option to sacrifice the ability to shoot at a 100 yard target.
- A natural solution to the fixed taper rail dilemma is the adjustable scope base/mount. These items allow you to adjust the angle that your scope makes on the rifle. In theory, this gives you the best of both worlds, you can achieve your 100 yard zero, while also using the mount to augment your adjustment range. If you have a good adjustable scope base that works well, is repeatable and accurate, then you're set. However it's very difficult to make such a mount well enough to meet the demands of modern ELR shooters.

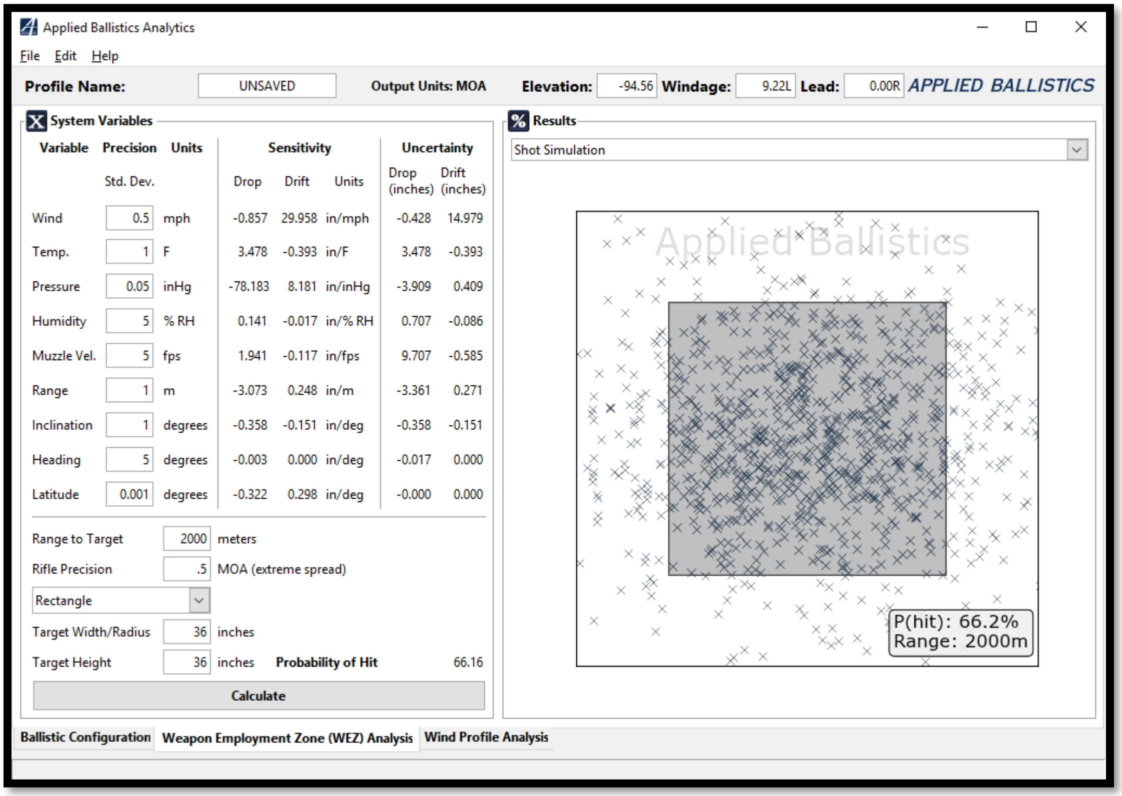
We're talking about maintaining ¼ MOA repeatability over hundreds of MOA adjustment! The way to test an adjustable scope base is to shoot a tall target at short range and measure to verify correct tracking. Problem is when you're dialing 200 MOA at 100 yards, it's not common to have a 17 foot tall target with a backstop! Other sighting solutions are being developed to overcome the challenges of extreme adjustment ranges such as refracting glass and periscope optics. One way or another, ELR shooters need to overcome the challenges of making such large sight adjustments accurately.

The Ivey mount is an example of an adjustable scope mount that allows you to adjust for up to 50 Miliradian (MILs) which is about 170 MOA.

Ballistic Predictions

For normal ranges, the bracket of drop and drift you have to correct for is not very extreme in terms of your target size. For example, suppose you have 25 MOA of drop and 3 MOA of wind deflection at 1000 yards and you're shooting at a 20" target (2 MOA). You could miscalculate your drop by 1 MOA which is 4% of total, and still hit the target. You could miscalculate the wind by 33% and still hit the target. Now suppose you're trying to hit the same size target at twice the distance. First of all, you have way more than twice the drop and drift to account for, but the margin for error is also much narrower because the target is now 1 MOA instead of 2. At 2000 yards you're looking at about 100 MOA of drop and 9 MOA of wind for the same round. Since the target is now only 1 MOA in diameter, you can only miss by ½ MOA which is only a 0.05% margin for error on drop! You can miss wind by ½ MOA also, which represents 5% margin for error on your 9 MOA wind call. It's easy to see how critical it is to have a highly accurate ballistics solver, and know how to use it.

Also, secondary effects such as spin drift and Coriolis come into play a great deal more at ELR as well. Spin drift rarely amounts to more than 5" to 10" at 1000 yards. However at twice the distance, spin drift alone can easily exceed 3 or 4 FEET.



Applied Ballistics Analytics software allows you to do highly refined ballistic analysis including hit percentage using custom drag models which are derived from live fire measurements.

Coriolis depends a lot on your latitude and direction of fire. For typical conditions, it's not uncommon to have 2 FEET or more of Coriolis drift in the vertical and horizontal direction.

It goes without saying that neglecting these secondary effects will result in complete misses of practical sized (3 foot) targets, and cannot be neglected like they often can at normal long range.

Modeling aerodynamic drag of your bullet becomes a big deal as well. Typically we use Ballistic Coefficients (BC's) to model the drag of our bullets in reference to standards like G1 and G7.

There can be some mismatch between our projectiles drag and the standards but it's normally not enough to cause concern out thru supersonic ranges. However when shooting ELR, it becomes incredibly important to model the drag of your specific bullet with great accuracy. An error of just 1% in modeling the drag of your bullet can cause a miss of over 2 ½ FEET at 2000 yards. Even the most accurate BC's are only good for a range of velocities and typically aren't accurate enough to support first round impacts at extreme range.

Bottom line; to achieve success with first round impacts in ELR requires a more sophisticated and complete ballistic solver.

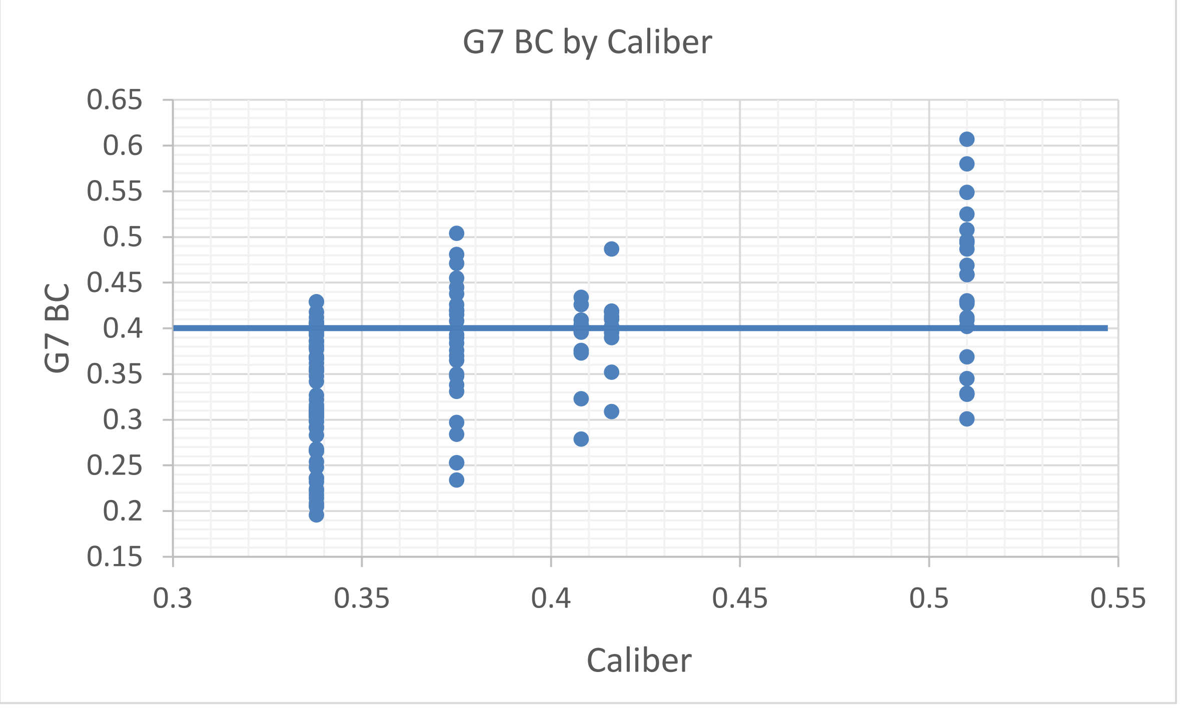
Ballistic Performance

Whatever the challenges of ELR shooting are, they're somewhat mitigated by high performance equipment. Push a super high BC bullet at super high velocity and you have the baseline for success at extreme range. Superior ballistic performance is great, but you need to harness the performance in a repeatable, consistent form or it's not much good.

Ballistic Performance – Bullets

We just stated in the section on ballistic predictions that BC's aren't typically accurate enough to support first round hits at extreme range which is true. However BC's can serve a purpose as a comparative measure.

G7 BC's of typical medium caliber bullets in the .243, .260, .284 and .308 caliber range from the high .2's to the high .3's. Some of the best .338 caliber bullets have G7 BC's which reach .4 which is the range of most bullets used in ELR. When considering a rifle build for any application, it's important to consider the bullet options available in that caliber which suit your needs. For ELR, you really want to stick with bullets having G7 BC's above .4. Here's a brief count of bullets with G7 BC's above .4 by caliber: .338: 8 out of 63, .375: 11 out of 26, .408: 4 out of 10, .416: about 6 out of 11, .510: about 17 out of 22.



There is a lot of information to be gleaned from the above listing and chart, and many questions come to mind as well. First, we can see that the availability of bullets in the .408 and .416 calibers is not very good. There's less than ½ the bullet selection in these calibers as compared to any other .338+ caliber. .510 caliber has the greatest selection of bullets with G7 BC's above .4 which is expected because it's the largest caliber. .375 is very well represented, having the most options of any large caliber besides .338.

There are only 5 .50 caliber and 1 .375 caliber bullets which have G7 BC's over .5. These are very long and heavy bullets for their caliber which can be difficult to get consistent performance from due to: recoil, excessively long bearing surface (in some cases), highly depressed muzzle velocities, and the challenge of finding a suitably slow burning powder for such heavy bullets in large cartridges. This is a good Segway into the next section…

Ballistic Performance – Trade-offs for consistency

If you only look at the BC's of the available bullets, you may be tempted to gravitate toward those .5+ BC options. BC is important, very important for ELR shooting but remember it's only one piece of a large system that all has to come together to achieve a desired result. It's important to balance all the elements to truly optimize the overall system.

Take those .5+ BC .50 caliber bullets for example. Those bullets are in the 1000-1100 grain weight range. The amount of recoil generated by those bullets from just a standard 50 BMG cartridge is incredibly unsettling and not conducive to accuracy or precision. Also, the muzzle velocity will be highly depressed for such heavy bullets. These bullets were tested from a 46" long 1:10" twist barrel chambered for the standard 50 BMG cartridge and the muzzle velocity was only in the 2300 fps range, and groups were not good.

When considering a bullet for ELR, you'll need something that's got a G7 BC above .4, and is also practically shoot-able.

Another trade-off in the ballistic performance vs. consistency spectrum is barrel length. Many shooters want to maximize barrel length to get as much muzzle velocity as possible which is good reasoning. However don't forget the other effects of a long barrel. Guns with barrels which are too long and heavy can be difficult to shoot well for various mechanical reasons. In my experience, long barreled rifles (longer than 30") are typically harder to maintain reliable precision with, as well as being more difficult to hold a zero. The precision problems stem from the long barrel time with a heavy bullet; the system has too much time and impulse to move while the bullet is in the barrel. Also, any harmonics or other similar effects that may be present are only amplified by the longer barrel. In my experience, shorter barrels are better able to shoot small groups and maintain zero. Maintaining zero is of the utmost importance for any rifle shooting discipline (apart from benchrest), and is especially important in ELR where matches and records highly value a first round (cold bore) impact. You can do everything right to put a shot right on the money at 2000 yards, but if you have a zero that wanders by ½ MOA randomly, cold bore shots are a straight up gamble.

The last performance vs. consistency trade-off that we'll discuss is super high performance and wildcat cartridges. Cartridges which require fire-forming brass and/or burn out barrels in under 500 rounds will typically generate the highest ballistic performance in terms of muzzle velocity with heavy, high BC bullets. You have to think about what you're giving up with such a cartridge selection though. If you're shooting something that requires fireforming brass, in a rifle that only has a 500 round usable barrel life, that means if you want 100 pieces of brass, you may use 20% of your barrel life just fireforming brass! In this case, the plan is usually to fireform the brass in another barrel, or use a reduced charge to mitigate the problem. Nevertheless, it's a problem you won't have with a standard cartridge.

Barrel life is important, even if you have deep pockets and can afford to buy 5 barrels at a time. With such a high performance, high maintenance cartridge, you're highly unlikely to get the amount of practice that you can with a more nominal cartridge.
On the other end of the spectrum, consider a modest 338 Lapua Mag or 338 Edge. These cartridges can shoot a .4+ BC bullet at 2800+ fps, and easily go 1000+ rounds. Bullets and brass are easy, relatively inexpensive (compared to .375+ components) and available. You can likely get 2X to 3X the practice in with a standard 338 as compared to something radical at a fraction of the cost, and be highly competitive in any ELR event.

In summary, ballistic performance (high BC and MV) is very important in ELR, but you have to keep the entire system in mind and find an intelligent balance between performance and the other things that matter as well.

The ELR Shooting Discipline – what are the rules?

ELR shooting has been going on for many decades. Unlike formal competition which has been highly formalized in numerous disciplines at 1000 yards and closer, shooting at 1500+ yards has remained a fringe activity, and everyone does it differently. Some shooters enjoy the experience of lobbing rounds out there and eagerly waiting the several seconds to see the bullet strike somewhere near the target. Other shooters have a more deliberate attempt and are only happy when they can put the first shot right on the money. Until recently, there's been little effort to formalize ELR shooting into something with common standards, guidelines and goals. To this end, the ELR Central initiative was established by Applied Ballistics.

Jeff Brozovich from 'Long Range Only' putting cold bore shots 'on the money' at 1905 yards!

ELR Matches

ELR Matches are defined as matches having more than ½ of the targets past 1500 yards. ELR Matches typically employ steel plates which are 12"-36" round, square or rectangle shape. Hits are difficult to see with spotting scopes especially in heavy mirage so it's common to use strike indicators such as flashers or target cameras. Scoring is done on a hit or miss basis, with the point value of a hit being weighted by shot number and range. For example, a first round hit is worth more than a second round hit, and the point value diminishes with each shot. There are numerous ways to assign actual point values, but range and shot number are the driving factors. Most ELR competitors agree that serious matches don't involve *unlimited sighters* to walk shots in to a target. ELR group shooting events are rare, with most being accuracy (hit or miss) driven. This makes sense considering the tactical/practical nature of many ELR hunters and military shooters. A great deal of the effort going into ELR is driven by a desire to push the envelope to develop better equipment for the guys in uniform.

There is a great deal of freedom for match directors to invent their Course of fire for ELR matches based on the unique features of their terrain, facilities and creative ways of challenging competitors.

Round count can be an important factor in the course of fire for an ELR match. For those with super high performance dedicated ELR guns with short barrel life, the matches which require 50 or 100 rounds of ammo to complete are much less appealing than the lower round count events. It's not uncommon for some matches to cross-over from normal long range PRS style into the ELR territory. Matches like the Nightforce ELR – PRS at Q Creek Range have the majority of targets under 1200 yards, but also have a substantial number of targets at 1500+, possibly out to 2000 yards. A PRS match like this which has ELR components is an interesting challenge from an equipment perspective. What's the best suited rifle for an event like this; something that's optimized for the intermediate long range targets like a 6mm, 6.5mm, or 7mm which is common in normal PRS matches, or a dedicated .375 caliber ELR gun? With targets from under 1000 to over 2000 yards and a round count over 100, neither extreme is likely the best option. Rather an event like this may call for a middle ground, something like a 300 Norma or 338 Lapua which has the performance to reach 2000 yards, but is also practical to shoot a high round count including intermediate range stages.

It's clear that the ELR dedicated matches are the far end of the spectrum in terms of performance. The rifles which are built and optimized to compete beyond 1500 yards are not likely to be practical or useful in any other applications. The PRS style matches with ELR components are great ways to explore the versatility of different rifle platforms in search of the *best of both worlds*.

World Records

World records are always a hot topic of interest and debate. There have been numerous world records claimed in the past couple years which have all been amazingly long shots and have received a lot of attention. The issue that many ELR shooters have with these records is that there are no standards, rules or guidelines in place for determining actual records. It's generally accepted that the proclaimed world records do represent the greatest distance that rifle shots have been made and targets hit, however the number of shots required to make the hit and the size of the target are such that the accomplishment is not repeatable nor practical. The majority of the ELR community is interested in records which more closely align with their sense of practicality and determinism meaning the ability to hit a target on the first shot, and hit it repeatably with follow up shots thus demonstrating a mastery of target engagement at that range. Such accomplishments will naturally only be possible at much shorter ranges, maybe 2000 yards vs. the absolute max range of say 4000 yards, but the accomplishment carries a lot of weight due to the deliberate nature of the achievement.

Target size is also an important thing to standardize when speaking of world records, as well as rules covering equipment, timing, insuring cold-bore, etc. The set of guidelines published by ELR Central was established by polling a focus group of ELR shooters to determine what should be considered to be a legitimate record that the community could agree on and support as the universal standard. Basically the world record as defined by ELR Central is *the maximum range at which a shooter can achieve 3-consecutive shots on a 3 foot square target*, or simply: *"3 out of 3 on a 3 foot square".* Many details are stipulated in the ELR Central guidelines but this is the basic idea. No sighter shots, so the first shot must be an impact from a cold bore. Then, to demonstrate it's not blind luck, 2 consecutive follow on hits must be made within a short timeframe.

Conclusion

Extreme Long Range Shooting is a growing discipline with many interesting challenges. It represents the tip of the spear and is driving innovation in the state of the art for practical long range rifle precision. There is a recent effort to brings some standardization and organization to the world of ELR competition and records based on the collective vision of those engaged in the discipline. If you're someone who enjoys pushing the envelope, working to solve problems, optimizing balanced systems for a specific objectives, or just simply enjoy the thrill of shooting at things really really far away, I encourage you to explore the exciting world of Extreme Long Range Rifle Shooting!