Accuracy Considerations for Electronic Targets:

Mid and long range rifle competition

By: Bryan Litz

The use of electronic targets is a hot topic of discussion recently among rifle shooters. Several different companies have developed electronic targets and they're getting more common on ranges for both individual use in practice, as well as some matches being shot on them. The organizers of the 2016 F-class National Championships are planning to use electronic targets, so there are a lot of questions about their accuracy and general operation. This white paper shares some thoughts on the accuracy requirements of electronic targets for use in mid and long range rifle competitions.

Different types of accuracy

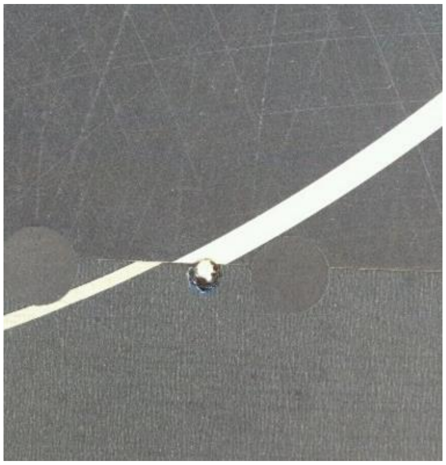
Any official adaptation of electronic targets would have to define a minimum accuracy requirement. What should that requirement be? There are several ways to consider this question. It's important to recognize the different types of accuracy that an electronic target has to resolve. First, the center of the aiming black has to be in alignment with where the computer thinks the center of the target is. The second kind of accuracy is in determining the placement of the shot in relation to the group and/or scoring rings (technically this would be called *precision*). Let's consider these two categories one at a time.

Calibration accuracy; is the center in the center?

If there's a problem with the alignment, or calibration, it will show up as a zero shift to the shooter. This kind of error is addressed by making sure the target faces are placed (and re-placed) in the same spot every time, and that the system is accurately calibrated as to where its center really is. How accurate does this calibration need to be done? Since the only thing this really affects is the shooters zero, it seems reasonable that the target center needs to be aligned within the ability of the shooter to adjust their sights. Typical scopes and sights adjust in ¼ MOA clicks. Some of the more precision optics have 1/8 MOA clicks. If the target center is located to within *½ of one click* (1/16th of an MOA) then it's inside of a single 1/8th MOA click which is beyond the sights ability to adjust. For 1000 yard targets, 1/16th of an MOA is 0.65". At 300 yards, 1/16th of an MOA is 0.20". *As long as the target center can be calibrated to within 0.20" at 300 yards and beyond, it can be considered "accurate enough".* Getting the center calibrated any more accurately than 1/16th of an MOA would be indistinguishable from *perfect* based on the increments of sight adjustment.

Single shot accuracy; how accurately can each shot be located in relation to the group and scoring rings?

As competitors, we would want something at least as accurate as what we're currently using. So, *how accurate are our current paper targets*? I'm not aware of an official specification on this, but anyone who's pasted enough target centers over an existing face has observed that the rings usually don't line up very well. Even if perfectly centered, the target rings can be up to ¼" - ½" too big or small at the corners. This situation with current paper targets shows that the *old way* of scoring targets on paper faces is far from perfect. With no current accuracy specification (that I'm aware of) for paper targets, it's difficult to baseline an accuracy requirement for electronic targets. The observed differences in the size of paper target centers suggests that maybe +/-¼" may be a reasonable specification for the accuracy of scoring ring sizes in electronic targets; because that's been sort of what we've been dealing with all along.


The accuracy of current paper targets is far from perfect.

Another detail related to accuracy of the shot location is the size of the bullet hole, which can be important for shots that are near a scoring ring; did the shot break the line or not? With current paper targets, those who shoot smaller calibers are less likely to break the scoring ring because the bullet hole is smaller. I've heard of something called the *30 caliber rule*, whereby bullet holes smaller than 30 caliber can be *plugged* with a 30 caliber gauge plug, and if that breaks the scoring ring, the shot is scored accordingly. In practice, I've never seen this rule actually applied. Shooters of sub-30-caliber bullets are simply at a disadvantage with current paper targets. Application of the 30 caliber rule on paper targets has the added problem of slowing pit service. Electronic targets could easily solve this problem by essentially treating every bullet as being the same caliber, and scoring accordingly. In other words, for scoring purposes, everyone's shooting a 30 caliber, having the 30 caliber rule in effect for every shot. Doing so effectively *improves* the accuracy of electronic targets over paper targets, or at least makes it fair for everyone regardless of the caliber you're shooting. In fact, for someone shooting a 0.224 caliber vs. a 0.308 caliber bullet, the improvement in accuracy is (.308"-.224")/2 = 0.042".

The large electronic targets used for long range, outdoor applications use microphones to locate shots. Microphones hear the sonic crack of bullets as they pass and triangulate the position of the bullets accordingly. The question has been asked about wind blowing the shockwave of the bullet, and how this affects accuracy. It's a good question, and easy to calculate the effect. Some electronic targets have the microphones inside a chamber (the target has a front and a back, making a chamber in-between). These *chamber-type* targets suffer no inaccuracies in the wind, so the following discussion only applies to those targets that have external microphones.

The shockwave of a bullet travels at about 1116 fps (more or less, depending on temperature). That's 761 miles per hour. Suppose a shot is fired thru the very center of the electronic target. With a calibrated target in no wind, the shot will register as centered. Now suppose you have a 10 mph crosswind. How much will the apparent position of the shot be affected based on the shock wave *drifting in the wind?* Well, the shockwaves are traveling at 1116 fps for about 3 feet laterally to the microphones. That takes 3/1116 = 0.0027 seconds. In that amount of time, a 10 mph crosswind (which is 14.7 fps), will shift the shockwave by 0.0027*14.7 = 0.040 feet, which is 0.48 inches. This apparent shift in the location of the shot is proportional to wind speed, so you could say that the shots will be shifted about ½" for every 10 mph of crosswind. This may sound like a big error at first, but consider that it takes a direct crosswind at the target face to make this happen. Typically, with all the target frames in the air, pit walls, target carriers, etc., it's rare that a full value wind exists right along the target face. There's something else called a boundary layer portion of airflow near the target face which prevents the plane of microphones from seeing the full crosswind value also. So the actual error is likely to be less than this calculated amount which assumes no obstructions to a crosswind. Also, consider the nature of target frames in high winds. You get a 10 mph crosswind and most targets catch enough wind to shimmy quite a bit. You can have at least an inch of wobbling back and forth when targets are exposed to high winds, which is exaggerated by the targets being pulled up and down; something that electronic targets don't need to do. In all, the inaccuracy caused by wind can be considered relatively minor in relation to other variables that are present with current targets in the wind.

Regarding the accuracy of individual shot location, consider that for every shot that's scored a lower value due to imperfect e-target function, a shooter will have an equal number of occurrences in which he's errantly scored the higher value. This isn't saying it's OK for e-targets to be wildly inaccurate, just saying that's the nature of random error; *you'll get lucky as often as you're unlucky.* The more accurate the system is, the less shots will be scored errantly. The issue of accuracy is only an issue for shots that are very close to the line, but it's all the same in the end.

As a further consideration, we can look to current standards for existing electronic targets which are used for indoor air rifle (10 meter ISSF) shooting. These targets have a 0.25 mm point which is scored as a 10.9. The accuracy requirement for those targets is 1/10th of the smallest scoring ring, which is 0.025 mm. Translating this to high power long range targets, F-class targets have the smallest scoring rings at ½ MOA. Applying the same accuracy standard of 1/10th of the highest scoring ring, we arrive at 0.05 MOA accuracy; which is 0.5" at 1000 yards and 0.15" at 300 yards.

Based on this existing standard, and the preceding discussion, an accuracy requirement of 0.25" seems like a reasonable accuracy standard for shot detection on mid and long range e-targets.

Finally, consider that whatever accuracy standard is decided upon would need to be actually measured and verified. If an accuracy standard on the order of 0.25" is established, it can be verified using typical tools such as rulers and tape measures; comparing group size and shot location in relation to scoring rings on paper targets vs. the electronic version. If the accuracy requirement is too demanding (on the order of 0.010" for example), then it becomes increasingly difficult to actually verify the targets are actually meeting the requirement, according to the rule. In other words, if the accuracy requirement is too demanding, it would make it too difficult for match directors to verify target accuracy and hold matches on electronic targets at all.

Summary

There are two kinds of accuracy related to electronic targets; how accurately the target is calibrated to center, and the accuracy of individual shot placement (second type is also known as precision).

- For calibration of center, 1/8th to 1/16th of an MOA is essentially *perfect* considering limitations of scope clicks. 1/16th MOA accuracy translates to 0.20" at 300 yards and 0.65" at 1000 yards. *If target centers can be located with 0.20" accuracy at all ranges, this can be considered 'good enough' in my opinion, because scopes don't allow shooters to aim any better.* In fact, if the calibration accuracy were loosened to 1/8th MOA (0.40" at 300 yards and 1.30" at 1000 yards), it would still be within the *practical* resolution of shooters with modern optics.
- Regarding accuracy of individual shot locations, 0.25" is a reasonable accuracy requirement based on the following:
    - 0.25" accuracy is better than we're doing with current paper targets.
    - 0.25" accuracy is well within the mechanical ability of target frames to hold targets still.
    - 0.25" accuracy is consistent with/proportional to existing standards in place for e-targets being used in short range competitions.
    - Match directors are able to verify 0.25" accuracy using normal means of measurement.

Some closing thoughts

This paper has primarily been about the accuracy of e-targets. There are many other issues and concerns related to rules and procedures when firing on e-targets. There's also a lot of up-side, not the least of which being safety. Safety is critically important in our discipline and e-targets would make rifle shooting much safer by *putting fewer people downrange.*

Also, consider that when shots are captured electronically, it's easy to update a match live on a network (internet) for everyone in the world to see! Imagine sitting at home, watching your friend shoot his string somewhere and watching him climb in the standings real time. Long-range shooting may actually gain some spectators, which leads to more interest, new shooters, and a stronger sport for all of us. Considering safety and all of the exciting potential that electronic targets offer, it's my opinion that it's time for us to commit to the future of our sport, go thru the growing pains, and get the rules and procedures of electronic targets ironed out. Hopefully this paper has provided some useful material on the accuracy part of the discussion.