APPLIED BALLISTICS
THE SCIENCE OF ACCURACY

Firing Solution Check List

By Doc Beech

The first thing that a lot of shooters consider when the predicted firing solution is not the same as the real world firing solution is “should I adjust the BC or the MV”. This depends on where the firing solution is off at. First things first, always make sure you are using the correct form factor (G1 vs G7). Shooters can and do get good results using the wrong form factor, but just because you do something wrong once and get away with it, doesn't mean it won't come back to bite you. So even if someone tells you that using the wrong form factor is ok, do yourself a favor to avoid any future issues and use the correct form factor. Second, where possible use Custom Drag Models. These are not G1/G7 BCs but are the actual drag data for the bullet. If you are going to use a BC then always look for a BC from our tested lab results. Lots of BCs on ammo boxes favor the marketing side of numbers. In the images here, you will see what kind of error can occur from calibrating the wrong variable. This is an important factor to consider.

To start with here is some general principles:

I) If the firing solution is off in the supersonic range, then you need to be calibrating the muzzle velocity.
II) If the firing solution is off in the transonic/subsonic range, then you need to be calibrating the DSF (Drop Scale Factor) or adjusting your BC.
III) MV & Ballistics calibration can be done outside the recommended ranges. Just understand that you are imposing a certain amount of un-avoidable error in your firing solutions. The Software/Apps/Devices will allow for it, but in some cases you will be doing more harm than good.
IV) Group Size is Important (Calibrations need 1/2 MOA 5 Shot Group Resolution minimum).
V) Incorrectly adjusting the wrong variable (BC instead of MV) will result is unintended, uncorrectable errors.

Just because your firing solution is off, doesn't always mean it’s the MV, BC, or the Solver that is off. Here are several things that can be going on that cause the solution to be off to check for. As you go through this checklist you will find space under each topic to for notes or confirmation remarks to that variable and a check box for when you are done with that section:

1. Are you using a Custom Drag Model? If not, are you using the correct form factor G1 vs G7. Custom Drag Models will always be more accurate, and will also negate any form factor short comings at ELR Distances:
   a. Custom Drag Models: http://www.appliedballisticsllc.com/cdm
   b. G1 vs G7: http://www.appliedballisticsllc.com/Articles/ABDOC2.3%20-%20Form%20Factors%20A%20Usefull%20Tool.pdf

NOTES:_____ Done ☐

2. Where did you get the G1/G7 BC from? It is recommended you only use BCs from our lab which have been properly tested, as it is not uncommon for marketing to be used in the BC on a box of bullets: http://appliedballisticsllc.com/ballistics-educationalresources/bullet-data/
    a. Averaged BCs vs Peak BCs. An Averaged G7 BC is the just like it sounds. The BC is averaged over a certain amount of the bullets flight path. Preferably through the transonic zone, which is how AB does it. A Peak BC has the potential to look better on paper, and is commonly used in marketing, but does not represent the bullets BC during flight and will lead to firing solution errors if used. Make sure if you use a BC you are using the Averaged G7 or a Segmented BC.

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3. How did you measure your velocity? Not all chronographs are the same, and the use of a poor or unreliable chronograph can cause issues: http://www.appliedballisticsllc.com/Articles/ChronographChapter.pdf. We recommend the Lab Radar as the most reliable and accurate currently on the market.

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4. How did you calculate your MV? Chronographs only measure velocity at their location, they do not measure Muzzle Velocity. http://www.appliedballisticsllc.com/Articles/ABDOC121_VelocityDecay.pdf

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5. Have you calculated and accounted for your powders Temp-Sensitivity? All rifle powders have a temperature stability factor between 0.2 and 3 fps of shift per degree of temp change Fahrenheit: http://appliedballisticsllc.com/Articles/Testing%20for%20Temperature%20Sensitivity%20-%20PT1.pdf

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6. SD of ammunition? Is your SD around 10 FPS? SD means that 2/3rds of your shots will fall in the +/- of your SD. 1/3rd will be outside of that. This is why its important to shoot groups at range. So you can determine if a shot was an outlier (flyer) or if changes need to be made. 10 FPS is the minimum you should be trying to obtain for Long Range Shooting. This will equal about a 1 MOA Vertical Spread at 1000 yards on average.

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7. Have you tested your scopes turret tracking? Scopes are not always perfect, and will have a variation in what they are marked as, and how they track as you click them. This is a common point of error, and every shooter should know how their turrets function. We recommend you perform the following test: http://appliedballisticsllc.com/Articles/TallTarget.pdf
    a. In apps this is generally called Sight Scale Factor (SSF) or Turret Correction Factor.

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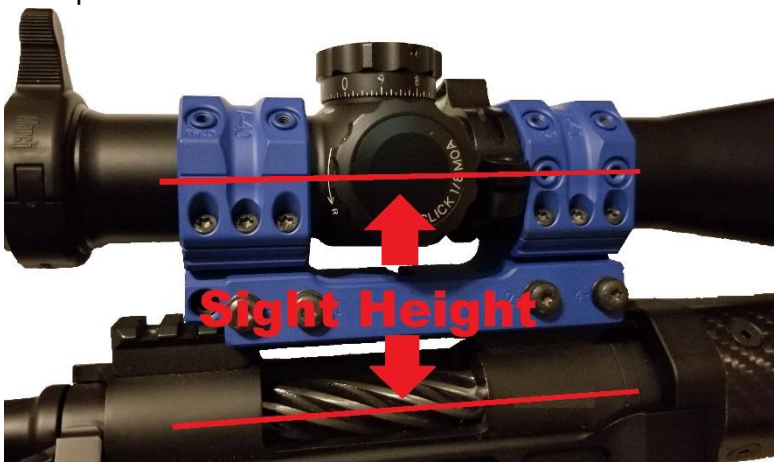
8. How did you measure Sight Height? Where from? The sight height should be measured at the center of the windage turret. It is the distance from the center of the bore to the center of the scopes axis.



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9. Parallax: Are you correctly using, and do you know how to correctly adjust your parallax? When adjusting parallax the crosshairs and image should not move when your move your head around behind the scope. This may not always mean 100% focus of the object, as things like mirage can distort the image.

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10. Mirage: Was there any mirage distorting the target image during the time of firing? Mirage can cause the targets image to displace from its actual location, knowing how

properly adjust for and manage mirage is important when determining the accuracy of a firing solution.

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11. TMOA vs SMOA. Not all scopes, ballistic apps & more are made the same. It is always good to double check is your scope working in TMOA or SMOA. It's also good to make sure the software you are using is working in the same units you are. 1" @ 100 yards (SMOA) is not the same as True MOA 1.047" @ 100 yards. All AB Software functions in TMOA unless otherwise specified.

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12. Verifying Range (and LRF Error). You would be surprised how inaccurate LRF devices can be. Especially some of the cheaper ones. Modern Advancements in Long Range Shooting Vol 2 shows some LRF testing, and the actual results, vs advertised results were disappointing in a lot of cases. A lot of LRF devices are good to +/- 3%, some are off by 5% and more. The further you go out, the more of an issue this is. Even with 1% accuracy at 1000 yards that's +/- 10 yards. 3% error at even 800 yards +/-24 yards. It's always good that a user verifies their LRF is providing accurate results. As you should do with all of your equipment.

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13. Direction of Fire + Latitude (Vertical Coriolis). This one is interesting, because it's so easy to account for. If your shots seem high, check to see your DOF. If you are shooting east, and your firing solution is high by 4 inches at 1000 yards. It might be Vertical Coriolis (vCor), and not actual error. For example, using a standard 308 175 gr setup. The shift if you were to shoot 1000 yards to the west, then shoot 1000 yards to the east and changing nothing else would be around 8 inches at a latitude of 40 degrees.

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14. Aerodynamic Jump (accuracy of wind measurement). We have this one figured out for you guys. But the number of times I have heard "I am off by a tenth of a mil, or a fifteenth of a mil" and they didn't account for AJ. It has become more well-known lately, and our software accurately calculates it for you. But none the less, it's there, and has been the cause of errors for shooters before.
    a. Aerodynamic Jump Zero Bias. This is when you had a crosswind that influenced Aerodynamic Jump in to your zero. For example. You zeroed your rifle in a 10mph crosswind. You would have one clicks worth of AJ built in to your zero.

So, when you add a click of AJ to the firing solution you now have twice as much AJ on the scope. This is easy to correct for, simply remove that one click out of the scope after you have zeroed.

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15. Barometric Pressure vs Station Pressure. This is a commonly misunderstood variable. Let us break this down into two sections to make it easier to understand:
    a. Barometric Pressure - This is the pressure at a measured location calibrated to that locations elevation. It prevents airplanes from hitting the ground when flying on instrumentation. When you input the Barometric Pressure in to the Altimeter on a plane it will read 0ft when on the ground. Bullets don't generally care about calibrating for the locations elevation, however this can input error in to a firing solution. To use this correctly you essentially need to know your elevation and back calculate to Station Pressure (Many ballistic calculators do this for you) but the difference in elevation between you and the weather station do cause errors.
    b. Station Pressure (Ambient Pressure) - This is the true pressure at the location you are at. Many devices like the Garmin Fortrex 701, Kestrel Elite, Sig Kilo 2400, RAPTAR-S…. read this directly. For accuracy purposes, this is what you should be using.

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16. Density Altitude – Density Altitude is a "reference" altitude for shooting. It allows you to generate charts using a mixture of readings which are calculated in to a single number. DA is very easy to skew, and not an accurate method for developing firing solutions. We recommend you avoid this.

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17. ICAO vs ASM: Most modern Ballistic Calculators use ICAO Standard Atmosphere (59 Deg F & 29.92 inHg) however others do still use ASM (59 Deg F, 29.53 inHg, 78% rh). All AB Calculators use ICAO and all AB Bullet Libraries are built on ICAO Atmospheric Standards. By using our systems, you can avoid any errors this would cause all together.

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18. Incorrectly doing a ballistic calibration. This one is common, so we have provided a guide on doing it properly: http://www.appliedballisticsllc.com/Articles/BallisticCalibration.pdf

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19. Positional Shooting Zero Shift. Are you shooting in the same position you zeroed at? Have you verified that you are able to hold zero when moving from Prone to Kneeling? It is not uncommon for a shooter's hold on the rifle to be different when shooting from different positions. This causes a shift in the zero of the rifle, and you should be training on always maintaining a zero in different positions. This comes with practice.

    NOTES:_____ Done ☐

As you can see its easy for a firing solution to appear to have an error in it, but it's just bad data being fed in to the solution. The actual calculating of a firing solution is simple physics, it is all the nuances you can find in the weapon platform that often lead to slight variations in predicted solutions. So when a firing solution is only "slightly" off, always double check your variables for why, it could be something as simple as turrets that are not tracking perfectly.

Ballistic Calibration is covered in great detail, in Accuracy and Precision for Long Range Shooting. https://store.appliedballisticsllc.com/ProductDetails.asp?ProductCode=0002 Included is how to properly do live fire verification with your ballistic calibration.

For more references you can visit our website at www.appliedballisticsllc.com where you will find over 30 educational articles: http://appliedballisticsllc.com/ballistics-educationalresources/articles/ and over 100 videos: http://appliedballisticsllc.com/ballistics-educationalresources/videos/.

You can also email us at anytime for direct assistance: support@appliedballisticsllc.com.