U.S. ARMY K. KASSENS

BALLISTIC CALCULATION FOR FIRST SHOT HITS

BY **KEN JAVES**

Until recently, developing firing solutions for accurately engaging targets past 500 yards was considered to be arcane knowledge possessed only by strange ballistics wizards who attended secret schools, spoke in tongues and had supernatural influence over the path of a bullet.

As it turns out however, ballistics is simply applied math and physics (not quite rocket science) and long-range solutions are now available to anyone with a smart-phone and an hour of study/tinkering with a ballistics app or program. I will breakdown the process for using the Applied Ballistics Mobile App developed by Bryan Litz at the Applied Ballistics Lab. I have found that most of the programs I have used follow roughly the same process, so applying the steps to a different program such as Shooter or apps from Hornady, Nosler and Knights Armament should be fairly straight-forward. I will be covering the high-points to get you started and leaving the nuances of the program to the detailed user guide (which can be found here: **http://www.appliedballisticsllc.com**).

STEP 1:

After downloading and installing your preferred application, the first step is to build a rifle profile that outlines the technical specifications of the rifle that you want to develop a firing solution for. It is important to keep in mind that, like any other computer program, the quality of the result is directly related to the quality of the data that is input. However, I will explain how to uncover errors and correct for them at the end.

In the example below I will be building a profile for a stock government issue M4A1 carbine with a Nightforce NX8 optic. Clicking the "+" symbol in the upper right corner will open the *Add Firearm* screen. *(figure 1)*

Name: M4A1 Carbine 14.5" Barrel with Nightforce NX8

FIGURE 1

FIGURE 3

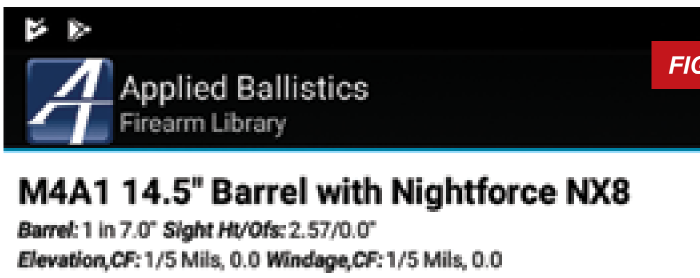


FIGURE 2

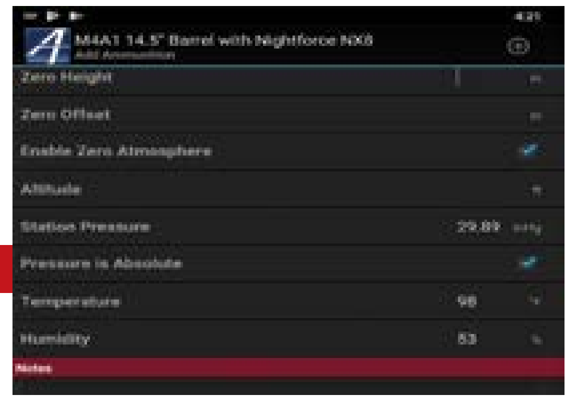


FIGURE 4

Barrel Twist: 1:7" Right Hand Twist

Sight Height: 2.57" - This is the distance from the center of the bore to the center of the optic reticle. I'm using a Geisselle Super Precision mount.

Sight Offset: 0" - A value must be entered here if the optic is offset to the left or right of the bore (e.g. Russian PSO Optics).

Reticle: Nightforce MOAR - There are a number of reticle options available from various optic manufacturers; since the FC-Mil reticle for my optic is not available I selected the closest option. Selecting *Mildot* from the menu will satisfy most circumstances.

First Focal Plane: This is selected since my optic is FFP, where the reticle size never changes in relation to the target which means the scale is correct regardless of the magnification setting (so the following blocks for maximum and minimum magnification do not apply). This is in contrast to a second focal plane optic where the scale is only correct (for ranging and holds) at one magnification, typically maximum.

Elevation/Windage Units and Gradation: Mils with a .2 Mil gradation (1/5 fractional). This is simply the turret adjustments for both windage and elevation. Mil or MOA can be selected with corresponding gradations.

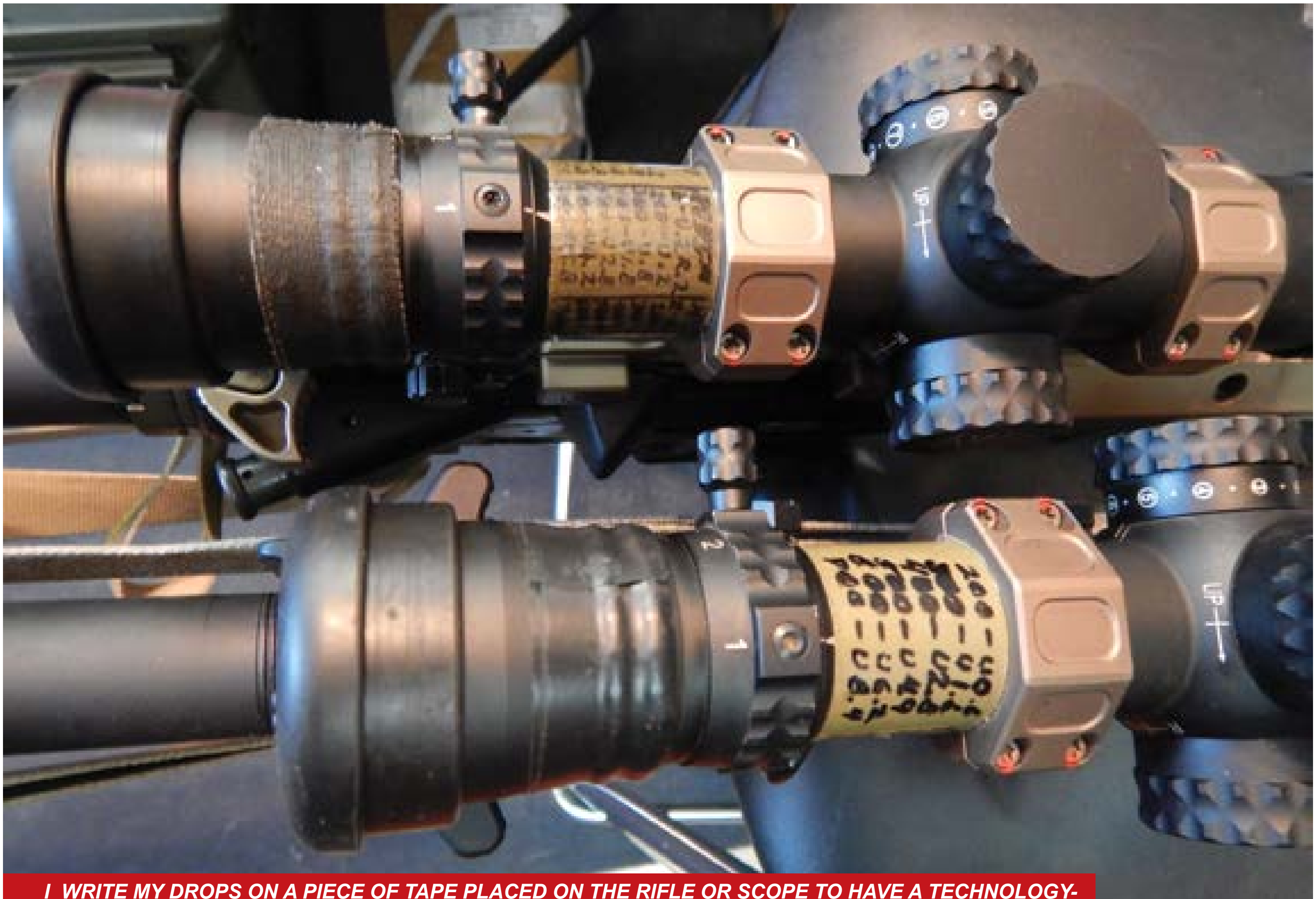
Lead Unit: Mils - Typically the same as your reticle to allow for holds on moving targets.

Elevation/Windage Correction Factor: This is used if your optic does not function as advertised. If you dial 10 Mils but the bullet impact only moves by 8 Mils you will have to input a correction factor to allow the program to produce an accurate result.

STEP 2:

Once the rifle and optic profile is completed a click on the " +" in the upper right corner will save your profile and bring you back to the inventory screen, which now has the profile you just constructed. *(figure 2)*

This time, instead of clicking on the "+" in the right corner, you will select the rifle profile which will then bring you to the ammunition library screen. *(figure 3)* Hitting the "+" on this screen will allow you to enter an ammunition profile for your rifle using a similar process. I suggest selecting a bullet from the extensive library vice trying to input the data manually. For the purposes of this example I will be selecting ".224 Bullets", then "Military" (a new addition with the latest update), followed by "Military AA33-M855" which is the closest mathematical equivalent to the issued 62 grain "green-tip" projectile. Next, an option will pop-up allowing the selection of a drag model. The options include G1, G7 and "Custom". These are mathematical model representations of various projectiles. The oldest, G1, profile resembles a pistol bullet with a conical nose and flat base. The G7 model more closely models a streamlined modern



I WRITE MY DROPS ON A PIECE OF TAPE PLACED ON THE RIFLE OR SCOPE TO HAVE A TECHNOLOGY-INDEPENDENT REFERENCE FOR ELEVATION ADJUSTMENTS OUT TO THE MAXIMUM RANGE

rifle bullet with an elongated body, tip and boat-tail. The model you select should most closely resemble the actual projectile you will be firing. I have selected the "Custom" option, which is based on ballistic testing conducted by Applied Ballistics and the $1.99 charge the custom drag model incurs is worth it to me to get a slightly more accurate solution.

If you used the bullet library, the next screen will have most of the bullet information filled-in already. The next input will be "Muzzle Velocity".

Muzzle Velocity: 2978.0 fps - I derived this number as an average from testing conducted on my chronograph. If you do not have a chronograph this number can be back-calculated through a process called *truing* but you will still need a number to start with. A starting MV can be determined through a bit of internet research or by the manufacturer's stated velocity typically found on the cartridge box.

MV Variation / Powder Temp: This is a representation of how much the velocity changes with temperature and can only be determined through testing the same lot of ammunition (powder) at various temperatures to see what the velocity change is. It is not necessary for an initial calculation and can be skipped for now.

Atmospheric Standard:
ICAO - Current Standard.

Drag Model: Custom

Ballistic Coefficient: This will be determined by the Drag Model that you selected.

Zero Distance: 100yds - The distance you zeroed the rifle at, where Point of Aim equals Point of Impact.

Zero Height / Offset: If true POA cannot equal POI, for whatever reason (such as gross turret adjustments), that offset can be accounted for here. **Zero Atmosphere:** The atmospheric conditions during the zeroing process can be input here to aid the program in generating more accurate solutions under varying conditions however it is not really necessary unless the zero distance is long enough to allow atmospheric conditions to affect zero impacts. This isn't typically found for 100 yard and closer distances. If entering the atmospheric data the best resource for the information at your shooting location is from a weather meter such as a Kestrel. One other advantage is a portable weather meter will give you the Station Pressure (or Absolute Pressure), which is the pressure (air density is the important bit) at the shooting location. Using the pressure at the shooting location also means an additional calculation involving your elevation and barometric pressure is not required. Some of the ballistic calculators (such as this one) will pair with the weather meter via Bluetooth and automatically enter the atmospheric information. *(figure 4)*

STEP 3:

Once the ammunition information is com-

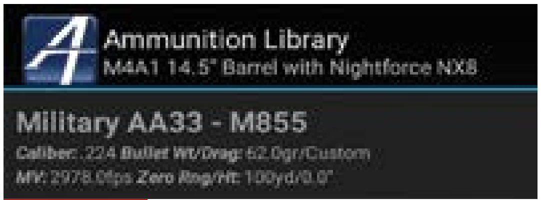


FIGURE 5

FIGURE 6

FIGURE 7

plete you can again click the "+" symbol in the upper right corner to save the data and take you to the ammunition inventory screen. *(figure 5)*

Select the ammunition profile you just created and the app will take you to the Environment Input/Shot Calculation screen. *(figure 6)* This is where the real magic happens and your firing solution or ballistic trajectory is computed.

Load Target: This option allows you to build a target library (similar to the rifle and ammunition profiles) if you regularly shoot at specific targets at specific locations. It is unnecessary for most purposes.

Distance: Enter the distance to a specific target or enter the maximum range you anticipate using the rifle to produce a trajectory or drop-chart. This app has a distance calculator as well (in the options bar) which will give you the distance to the target if you input the target size and its Mil measurement.

Look Angle: If you are shooting up or down at a target the angle can be entered here. Angles greater than 10 degrees can be significant, depending on the range. Most phones have a built-in inclinometer function which allows sighting down the phone case to get the angle. The "Get Look Angle" option in the AB app takes advantage of this feature and will automatically populate the angle field.

Move Speed / Angle: If shooting moving targets the movement information can be entered here.

Atmosphere Field: Current atmospheric data is entered in this field, which the program will compare to the atmospheric data gathered when the rifle was zeroed (and ammunition profile developed) to calculate the ballistic shift present under the new conditions.

Wind Speed / Angle: Current wind conditions are entered here and are most easily determined by using a portable weather meter, such as a Kestrel.

Spin Drift: Due to the spin imparted on the bullet by the rifling, the bullet will tend to drift away from the point of aim. This is a typically minor effect inside of 500yds, but it can become more pronounced as the distance increases. *(figure 7)*

Coriolis Effect: Another minor effect, this one is based on the rotation of the earth and the effect varies with the shooting direction and latitude. This is typically not a necessary component of the calculation unless attempting to hit a small target at extreme ranges.

Once the pertinent environmental and target data is entered, two options are present. One is to provide a firing solution for a single shot on the target and will only provide the information for that shot. *(figure 8)* The other provides the bullet's trajectory from the muzzle out to the distance you entered in the target field. *(figure 9)* In my opinion, the trajectory option provides the most practical information because, from it, I can produce a drop-chart that I then stick on my rifle which allows me to rapidly adjust for targets at various ranges without having to consult the app.

STEP 4:

Now that a firing solution has been calculated the next step is to test it and ensure that the digits match up with reality. This process is called "Truing" and it is used to compensate for any variables that aren't already accounted for in the program and it can also be used to refine the muzzle velocity from Step-2 if you don't have a chronograph.

Truing / Ballistic Calibration: To get the best result from the truing process you will want to select a target as far out as you can, but within the range where the bullet is still supersonic (above 1125 fps). The reason for keeping the velocity above the transonic range is ballistic programs can still accurately predict the performance of the projectile,

FIGURE 8

things get fuzzy when bullets drop out of supersonic flight and predictions can be inaccurate. If you look at the trajectory chart from Step-3 you will notice that the velocity at 800 yards (1123.1 fps) is highlighted in red. This is the point that the program predicts the bullet will be sub-sonic. If I have ideal conditions and the range available, I would place a target at 700 or 750 yards for truing. I will then use the windage and elevation settings from the chart for that range and see where the bullets impact on the target. If the bullet impacts at my point of aim no further adjustment is necessary and I know the app has given me a reliable solution. This can be done at closer ranges, but the confidence in the result will be reduced. If my bullets do not impact at my point of aim I then measure how far off the windage and elevation is. This can be measured through a spotting scope using the Mil scale, physically measured on the target itself, or the scope dialed until the bullets impact in the desired spot and noting the difference, which is the preferred method. The Ballistic Calibration tool is available from the Single Shot or Trajectory Screens in the menu in the upper right corner. In the example below I noticed a difference of .2 Mils in what I had to dial to hit the target at 750 yards.

You can see the resulting difference in the Muzzle Velocity displayed in the Calibration Results area and if I want that updated and

Range (yd)	Path (in)	Path (mils)	Drift (in)	Drift (mils)	Velocity (fps)	Energy (ft-lbs)	TOF (s)
800	-214.7	U7.4	0.0	0	1123.1	173.7	1.32
775	-193.8	U6.8	0.0	0	1160.1	185.3	1.254
750	-174.7	U6.4	0.0	0	1202.7	199.1	1.19
725	-157.2	U6.0	0.0	0	1247.5	214.2	1.129
700	-141.0	U5.4	0.0	0	1294.4	230.7	1.07
675	-126.0	U5.0	0.0	0	1342.6	248.2	1.013
650	-112.3	U4.6	0.0	0	1391.9	266.7	0.958
625	-99.7	U4.4	0.0	0	1442.0	286.3	0.905
600	-88.2	U4.0	0.0	0	1493.0	306.8	0.854
575	-77.6	U3.6	0.0	0	1545.0	328.5	0.805
550	-68.0	U3.4	0.0	0	1597.5	351.3	0.757
525	-59.2	U3.0	0.0	0	1650.8	375.2	0.711
500	-51.1	U2.8	0.0	0	1705.5	400.4	0.666
475	-43.9	U2.4	0.0	0	1760.2	426.5	0.623
450	-37.3	U2.2	0.0	0	1816.0	454.0	0.581
425	-31.4	U2.0	0.0	0	1873.0	482.9	0.54
400	-26.1	U1.8	0.0	0	1929.7	512.5	0.501
375	-21.4	U1.4	0.0	0	1988.2	544.1	0.463
350	-17.3	U1.2	0.0	0	2046.9	576.7	0.426
325	-13.6	U1.0	0.0	0	2107.3	611.3	0.389
300	-10.5	U0.8	0.0	0	2168.1	647.1	0.354
275	-7.8	U0.6	0.0	0	2229.7	684.4	0.32
250	-5.5	U0.6	0.0	0	2292.2	723.3	0.287
225	-3.7	U0.4	0.0	0	2356.5	764.5	0.255
200	-2.2	U0.2	0.0	0	2421.6	807.3	0.223
175	-1.2	0	0.0	0	2487.4	851.8	0.193
150	-0.5	0	0.0	0	2553.8	897.8	0.163
125	-0.1	0	0.0	0	2621.8	946.3	0.134
100	0.0	0	0.0	0	2691.5	997.3	0.106
75	-0.2	0	0.0	0	2761.6	1049.9	0.078
50	-0.7	U0.4	0.0	0	2831.9	1104.0	0.052
25	-1.5	U1.6	0.0	0	2905.0	1161.8	0.025
	-2.6	0.0	0.0	0.0	2978.0	1220.8	0.0

FIGURE 9

saved across the profile I simply hit "Apply Calibration" and the result will be implemented, saved and available for future calculations with this rifle and ammunition profile. *(figure 10)*

STEP 5:

The last step I like to use is to write my drops on a piece of tape placed on my rifle or scope so that I have a technology-independent reference for elevation adjustments out to the maximum range I anticipate employing my rifle.

As you can see from the above process, technology has once again made magic and mysticism available to the shooting masses. Using a ballistic calculation program or app can take a lot of the mystery out of long range shooting and reduce the amount of time and ammunition required to develop that particular skill. Apps that I have used range in price from free to about $30 and additional information on the nuances of each program is usually available from the manufacturer. ✓

FIGURE 10

BIO

*Ken Javes (**www.shibumitactical.com**) has over 19 years of military and security contracting experience to include multiple combat and contract deployments to South West Asia. He has served with Marine Infantry and Force Reconnaissance units. He possesses instructor certifications from multiple agencies and organizations, and has trained with some of the top military and competitive shooters in the country.*