User's Guide

SHOOTER'S

V3

REFERENCE

Revised
August 2014

PRACTICE SAFE FIREARMS HANDLING AND FOLLOW ALL SAFETY RULES!

index

introduction [getting started]

Shooter's Reference V3 is a ballistics calculator for sports shooting enthusiasts that features a classical physics-based projectile motion model, cartridge database, and several other useful tools.

The V3 ballistics model supports G1 and G7 drag models (as well as many others), BC (ballistic coefficient) and ambient weather conditions compensation yielding accurate bullet drop and wind drift solutions. For ease of use, Shooter's Reference has a built-in database of over 2,000 cartridges from Barnes®, Buffalo Bore®, CCI®, Eley®, Federal Premium®, Fiocchi®, Hornady®, Norma-USA®, Nosler®, PMC®, Remington®, Weatherby®, and Winchester®. In addition, the user can manually enter the required input parameters such as muzzle velocity and bullet weight.

Additional tools are included that aid sight-in calculations at the range, estimating the distance to a target, and performing mils and moa calculations.

Both imperial and metric units are supported.

Comments, complaints, suggestions, and questions are appreciated.

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WARNING!

PRACTICE SAFE FIREARMS HANDLING AND FOLLOW ALL SAFETY RULES! ALWAYS!!!

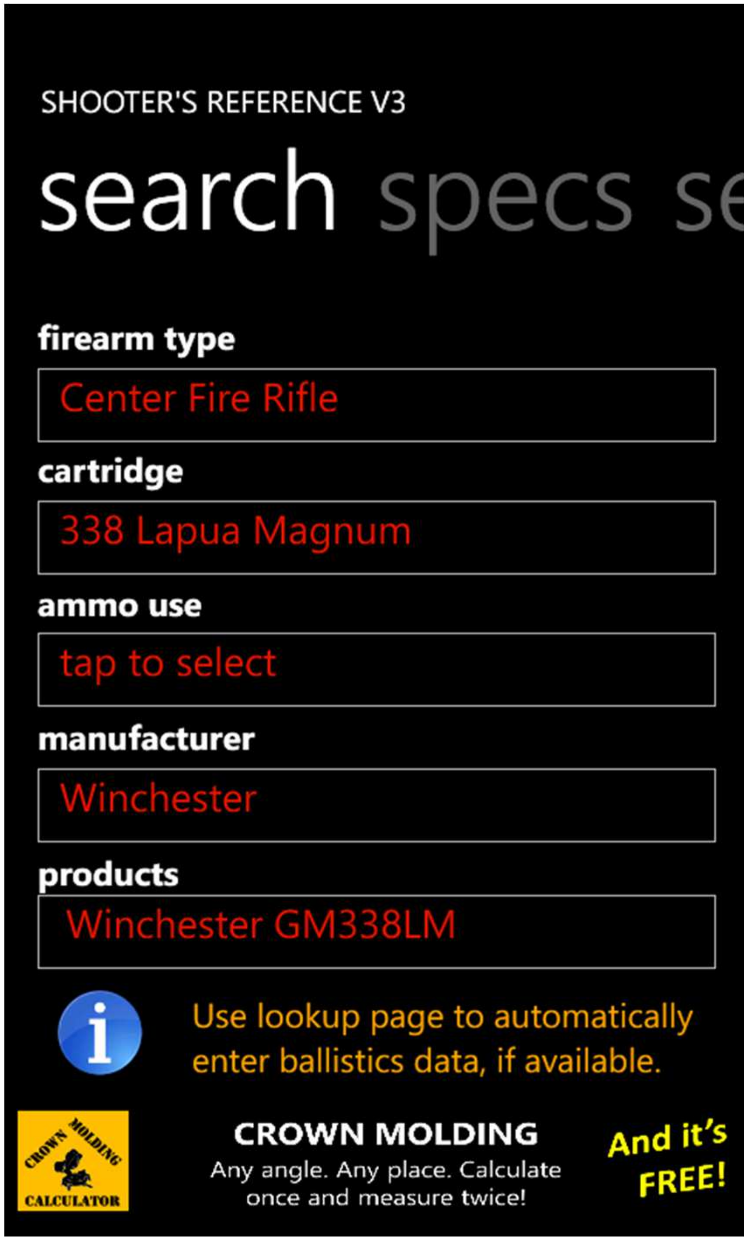
search [find your cartridge's specs in the built-in database]

Cartridge Database

In order to set up the ballistics calculator, there are a few parameters you need to know about your cartridge. We have included a database of over 2,600 popular rifle and handgun cartridges that can be searched simply by tapping the search boxes on the **search** page. Tap the **products** box to see the list of cartridges that match your criteria and to choose one. Note that a maximum of 100 products can be displayed. The best way to avoid that limit is to choose a **cartridge**.

The parameters required by the ballistics calculator are automatically loaded into the **setup** page when a product is selected. The following parameters are extracted:

- **Bullet diameter**
- **Bullet weight**
- **Ballistic coefficient (optional, not required)**
- **Muzzle velocity**
- **Muzzle energy (not used, but displayed)**



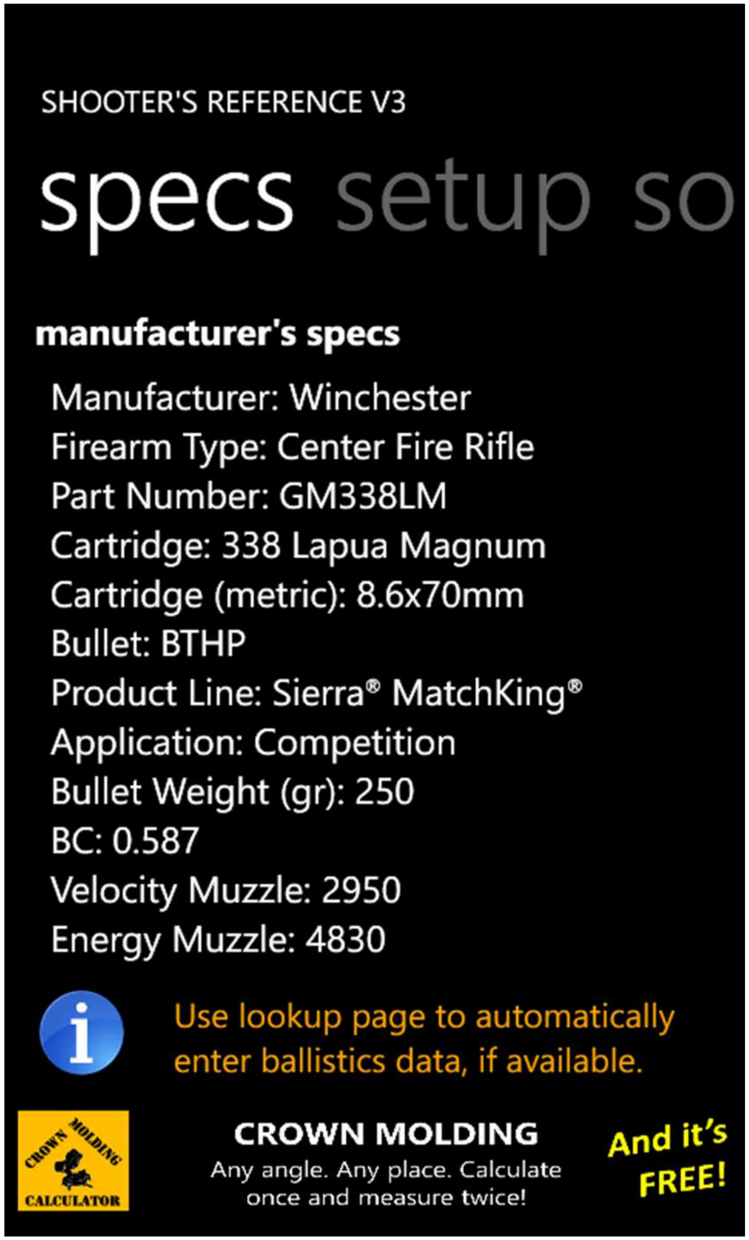
specs [view manufacture's data and description]

Cartridge Specs

When a cartridge is selected from the database, a summary of the its specifications is displayed on the **specs** page. The specs are from the manufacturer and are subject to change.

Typically, the following specifications are available:

- **Manufacturer, product line, and part number**
- **Cartridge and bullet description**
- **Typical application**
- **Bullet weight and ballistic coefficient**
- **Muzzle velocity**
- **Muzzle energy**



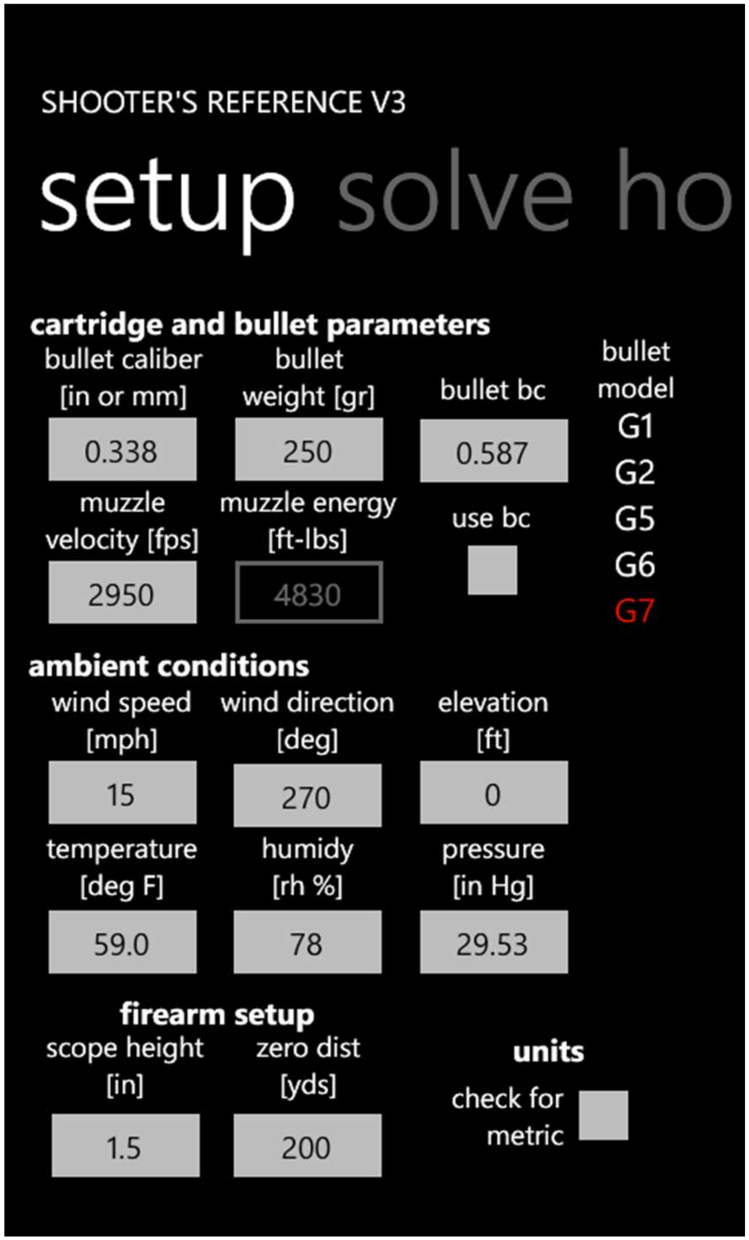
setup [setup model parameters]

Model Setup

Cartridge and Bullet Parameters

These parameters describe the cartridge and bullet.

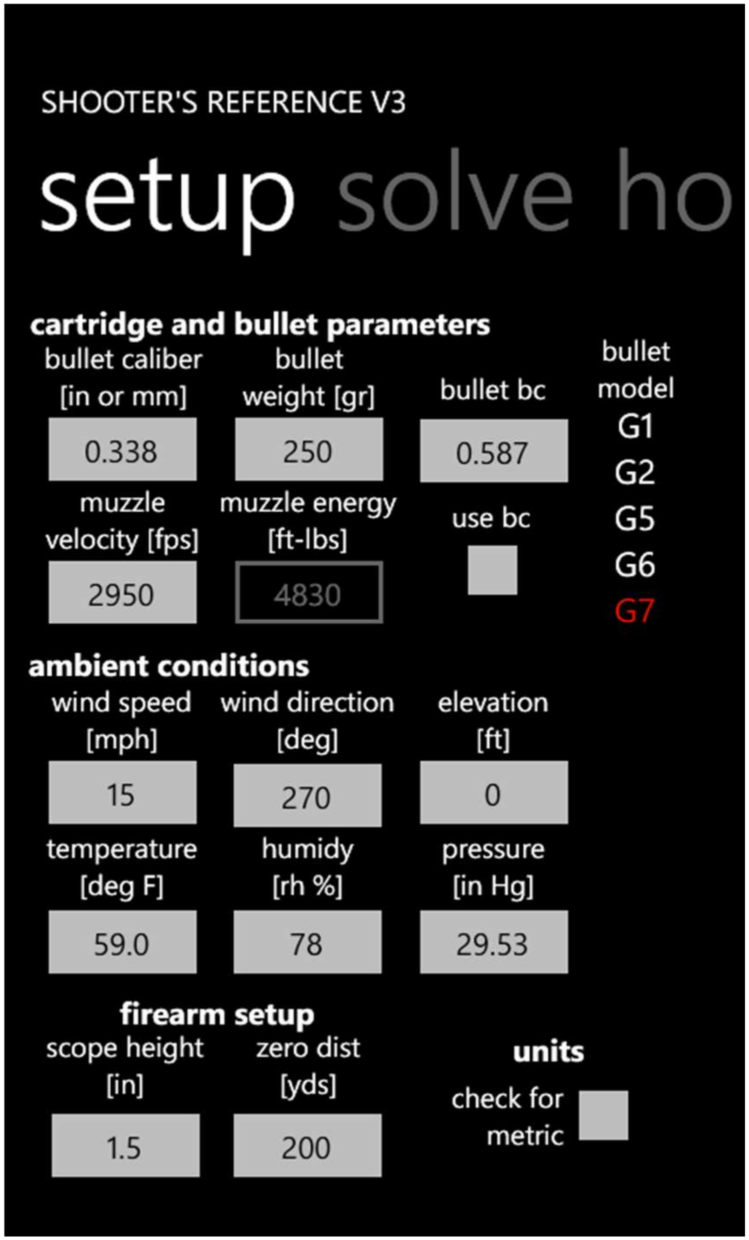
- **bullet caliber**
  - Required, inches or mm, depending common usage
- **bullet weight**
  - Required, always in grains
- **ballistic coefficient**
  - Only required if **use bc** box is checked
  - Default is to not use BC in ballistics model (yields best results)
  - Can be applied to any of the bullet models but most manufacturers only specify a G1 BC
- **bullet model**
  - Required, G7 default
  - G7 works best for low drag bullets
  - See page 30, **Standard Bullet Models** for more information



Model Setup (continued)

Cartridge and Bullet Parameters (continued)

- **use bc**
  - Not required or recommended
  - If checked, ballistics model applies BC to selected bullet model's drag coefficient
- **muzzle velocity**
  - Required, in fps or mps
- **muzzle energy**
  - Displayed for information only, in ft-lbs or Joules

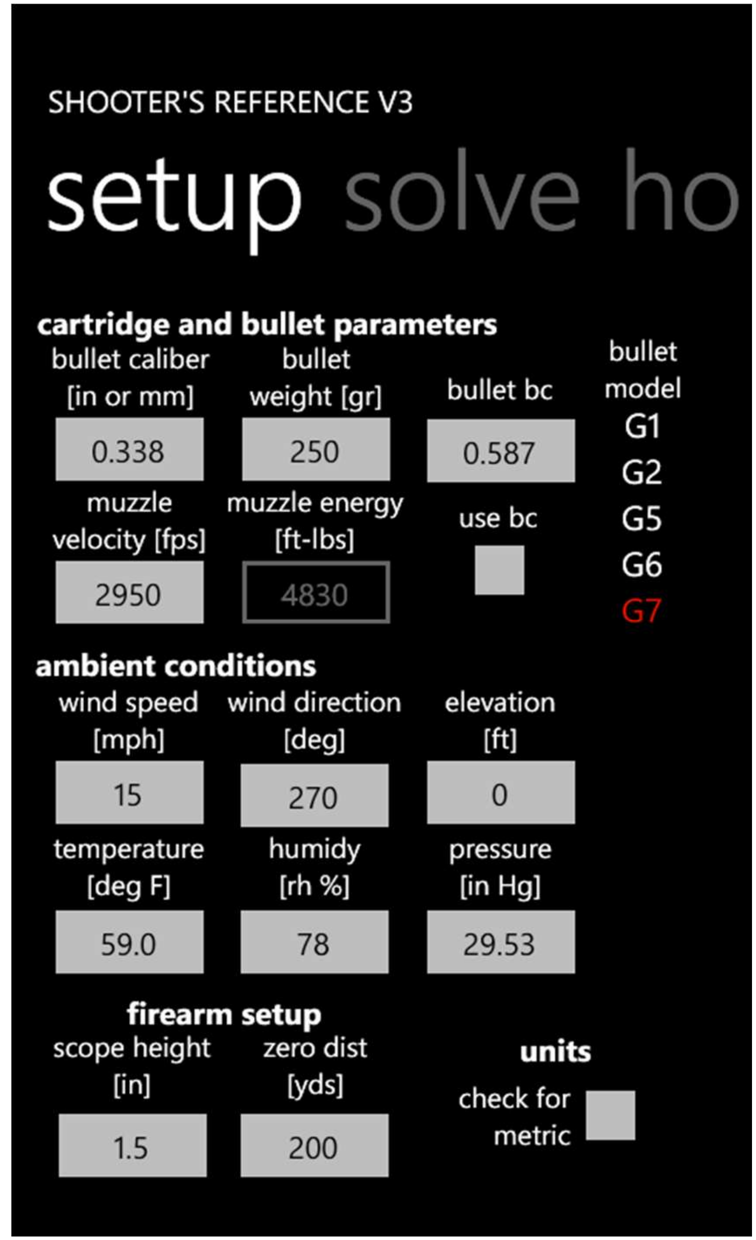


Model Setup (continued)

Ambient Conditions

Entering ambient conditions allow Shooter's Reference to calculate wind drift corrections as well as air density compensation. U.S. Army Standard Metro conditions are the default.

- **wind speed**
  - Optional, in mph or kph
- **wind direction**
  - Optional, in degrees, using meteorological convention (see illustration on page 13)
- **elevation**
  - Optional, in feet or meters above sea level)
  - If zero, temperature, humidity and pressure are used to calculate air density (most accurate method)
  - If non-zero, then altitude is used to calculate air density (better than no air density correction)



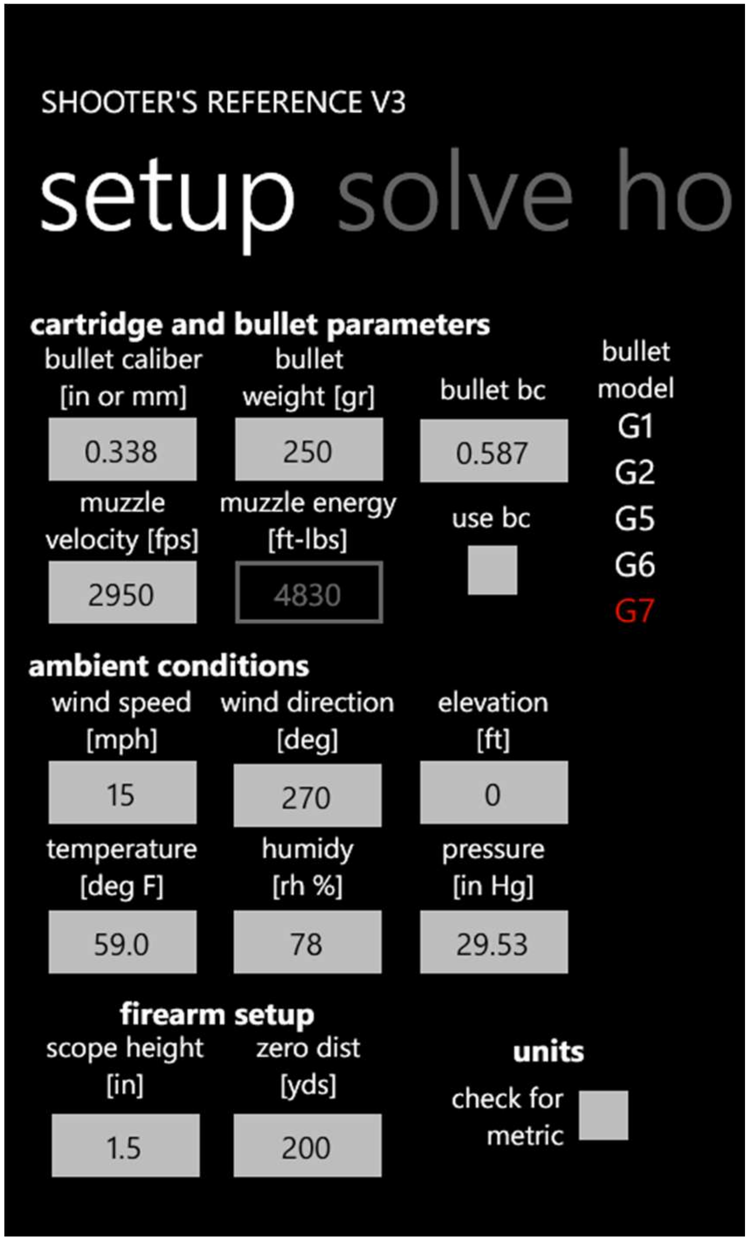
setup [setup model parameters]

Model Setup (continued)

Ambient Conditions (continued)

- **temperature**
  - Optional, in degrees Fahrenheit or Celsius
- **humidity**
  - Optional, in RH percent
- **pressure**
  - Optional, in inches of Mercury or hectoPascals

> ***Tip:*** *If exact ambient conditions are not available, a good guess at temperature and humidity while leaving the pressure at the default value will improve the ballistic model's results.*



setup [setup model parameters]

Model Setup (continued)

Firearm Setup

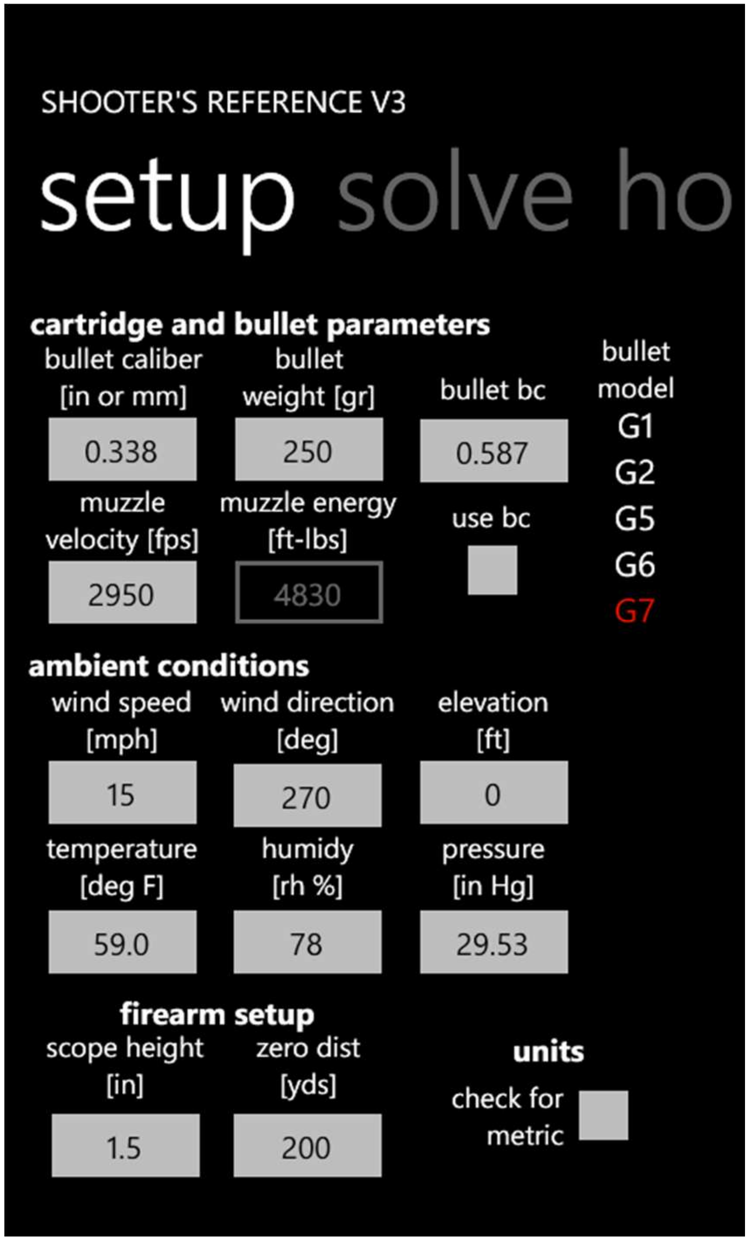
The model uses the scope mounting height and the zero distance to calculate the bore angle of the firearm relative to the line of sight. The centerline to centerline height of the scope relative to the barrel is critical to the accuracy of the model.

- **scope height**
  - The centerline to centerline height of the scope or sights to the barrel
  - Required, in inches or millimeters
- **zero distance**
  - Required, in yards or meters

Measurement Units

Metric units are used internally. Input and display units can be toggled at any time by checking/unchecking this box.

- **input units**
  - Required, in yards or meters

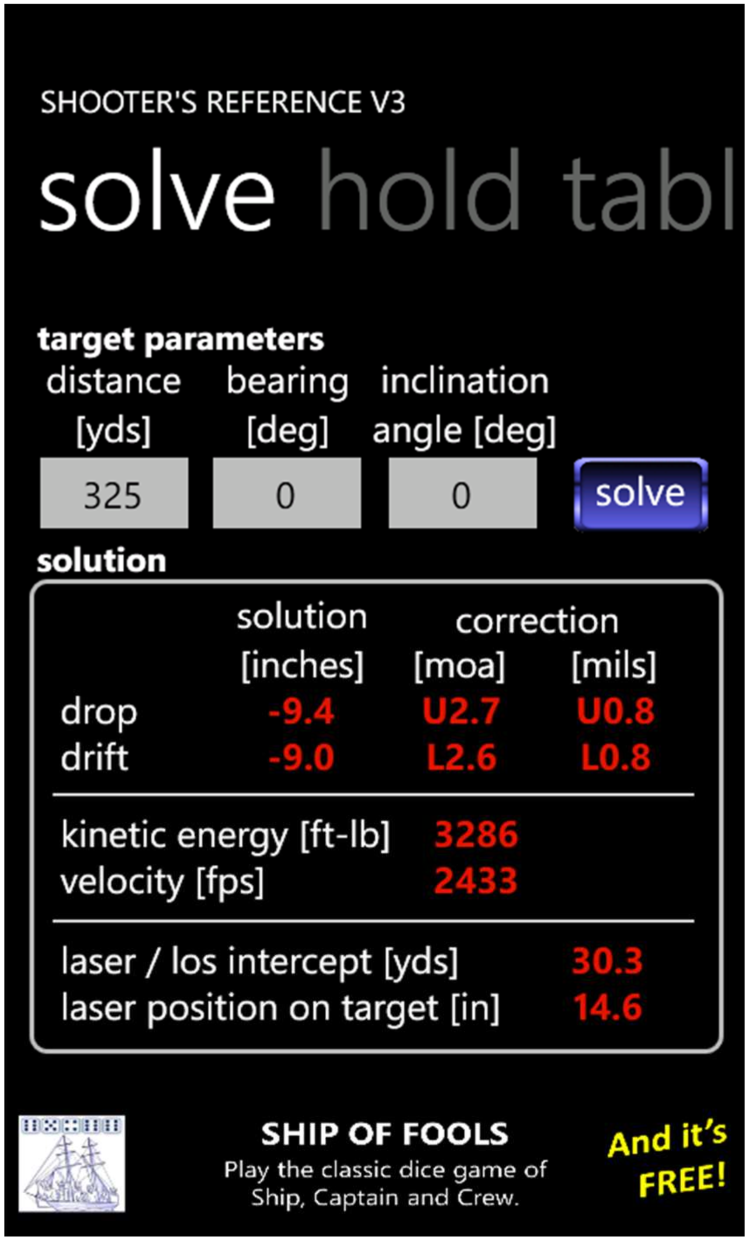


Find a Solution

The target distance, bearing, and inclination angle are entered on the **solve** page. Press the **solve** button to calculate the solution.

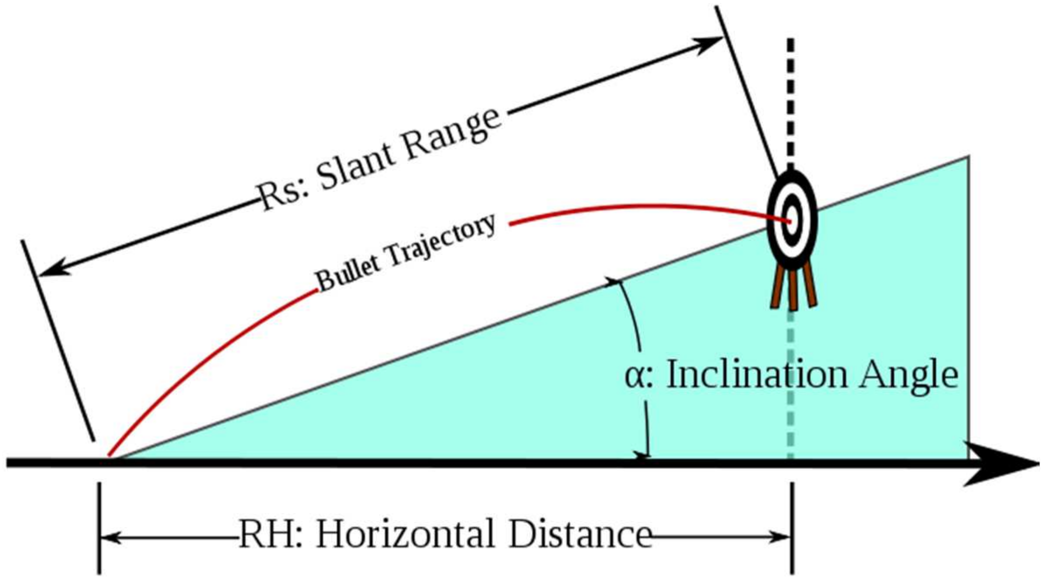
- **distance**
  - The line of sight distance to the target
  - Required, in yards or meters
- **bearing**
  - The target bearing
  - Required, in degrees
- **inclination angle**
  - The target inclination angle (see illustration on page 13)
  - Required, in degrees

The line of sight distance (also referred to as the slant range) is the straight line distance as measured to the target. The ballistics model uses the Rifleman's Rule to calculate the horizontal distance to the target. This compensates for uphill or downhill shooting situations.

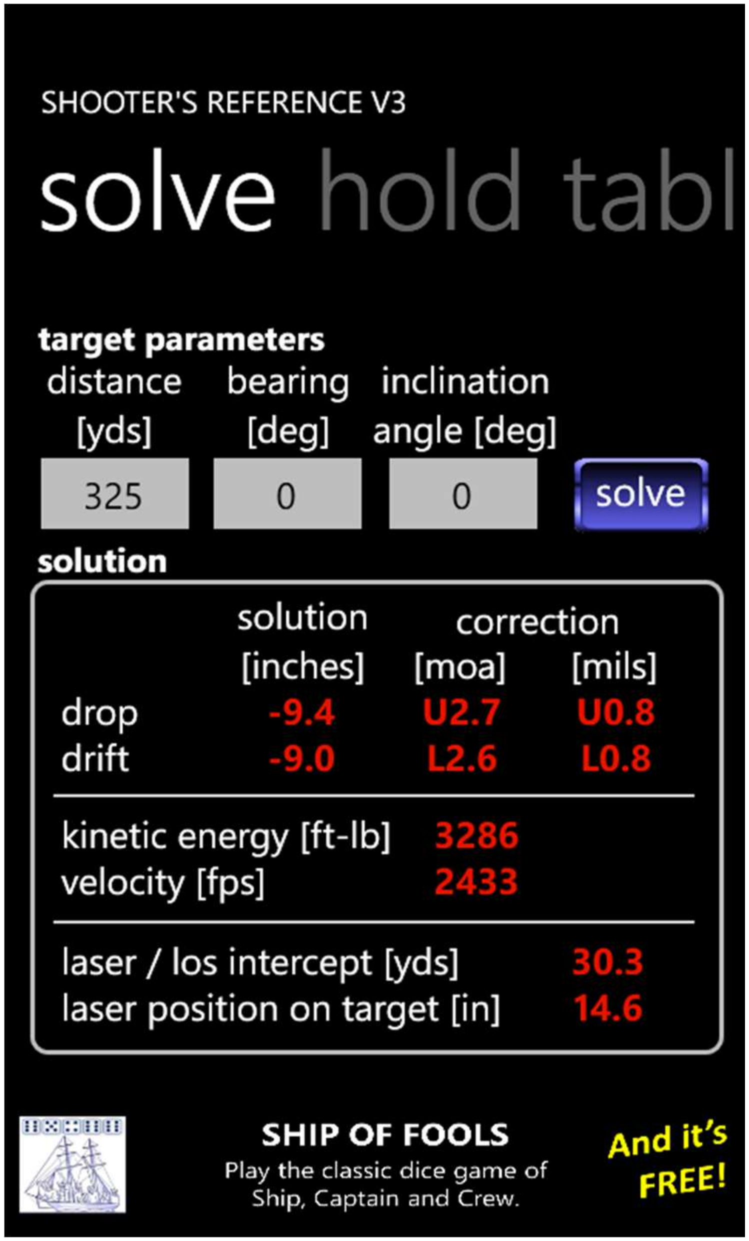


solve [enter target data and solve model]

The inclination angle is the angle of the target relative to the shooter. A 0° inclination is horizontal, flat ground. Positive inclination angles indicate an uphill shot while negative inclination angles indicate a downhill shot. Please refer to Wikipedia for an explanation of the Rifleman's Rule.

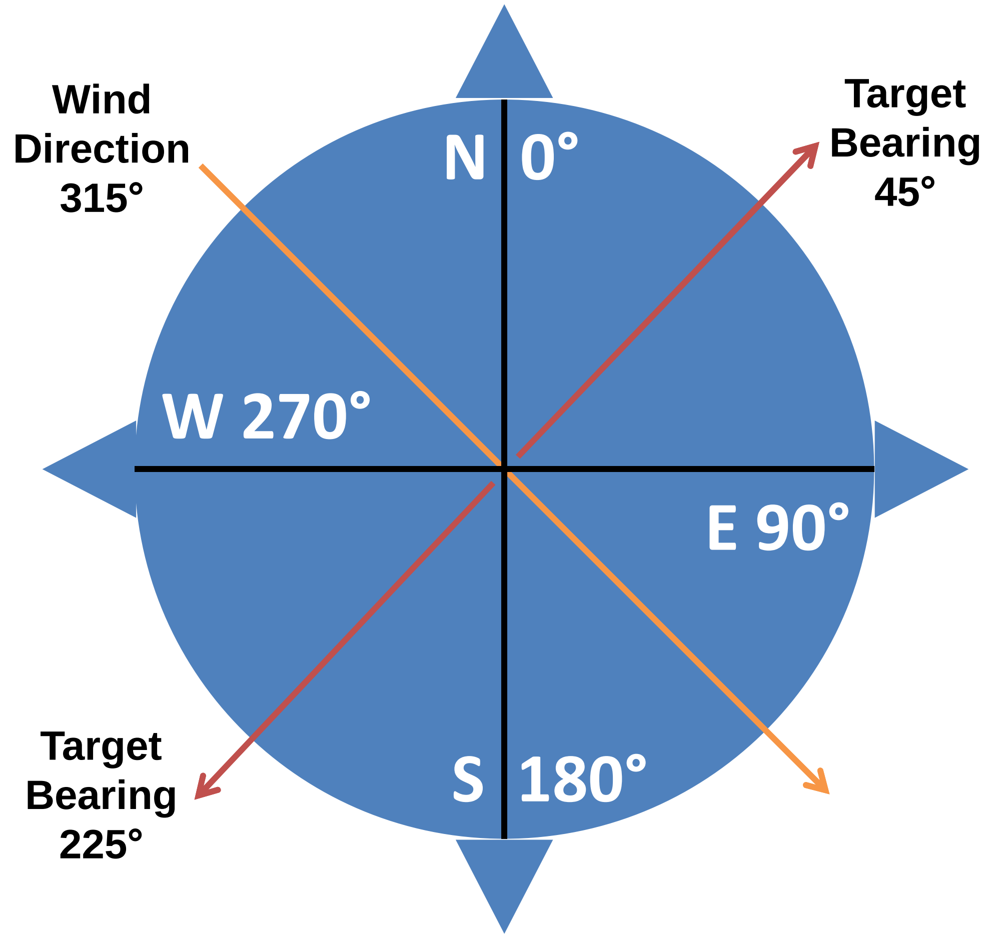


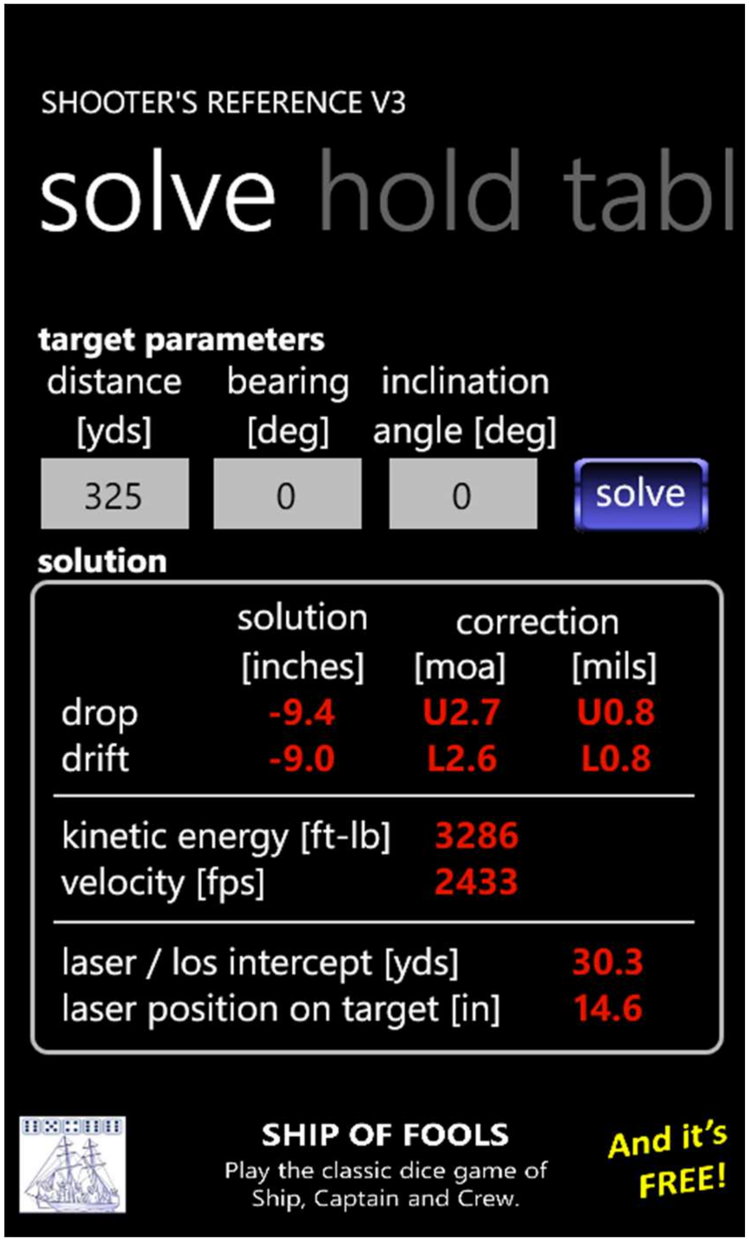
Source: http://en.wikipedia.org/wiki/Rifleman's_rule



solve [enter target data and solve model]

The **bearing** is the compass bearing of the target.





***Tip**: Target bearing is the direction in which the firearm is pointing. Wind direction is where the wind is blowing from (meteorological convention).*

solve [enter target data and solve model]

Click the solve button to calculate the solution.

Drop and drift are displayed in length units as well as mils and MOA's. "U" and "D" preceding a number refer to up and down while "L" and "R" preceding a number refer to left and right sight adjustments.

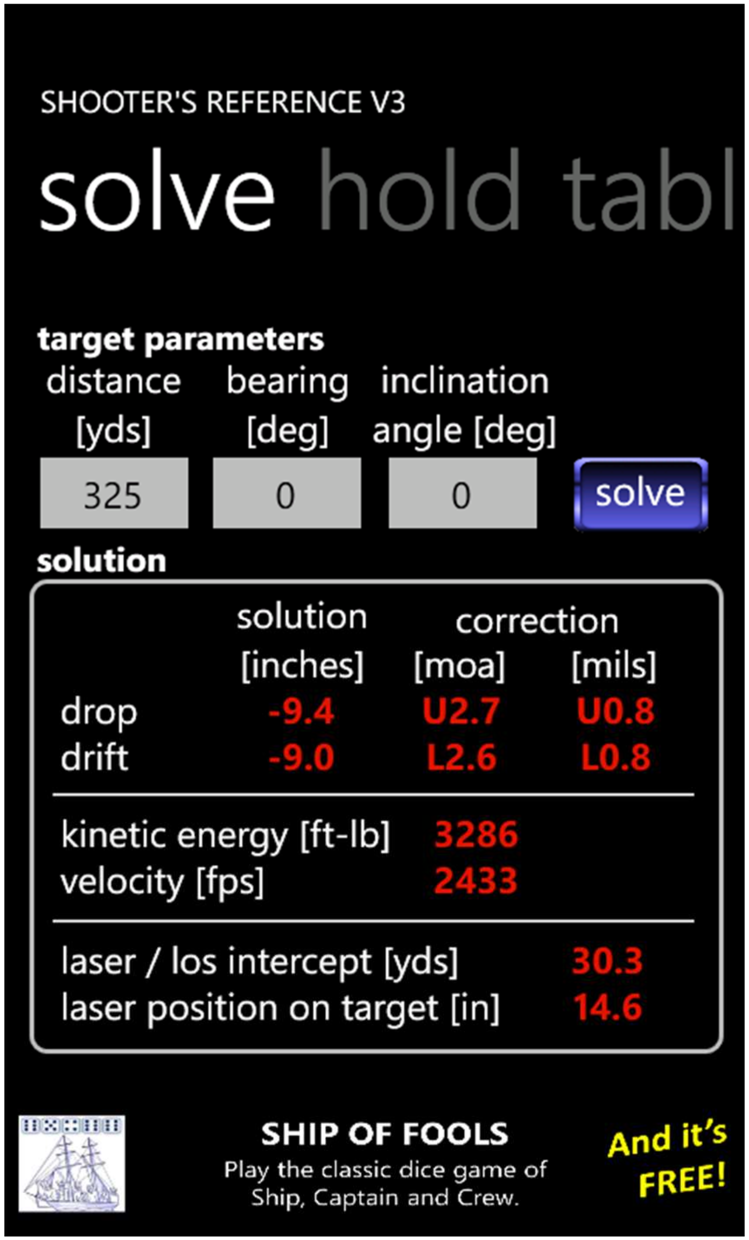
For example, in the screenshot to the right, the sights should be adjusted up 2.7 MOA or 0.8 mils to account for bullet drop. 2.6 MOA or 0.4 mils left must be dialed-in to account for wind drift.

The kinetic energy and bullet velocity at the target distance are also displayed. Kinetic energy is displayed in either ft-lb or Joules. Velocity is displayed in feet per second (fps) or meters per second (mps).

Bore Laser Sight

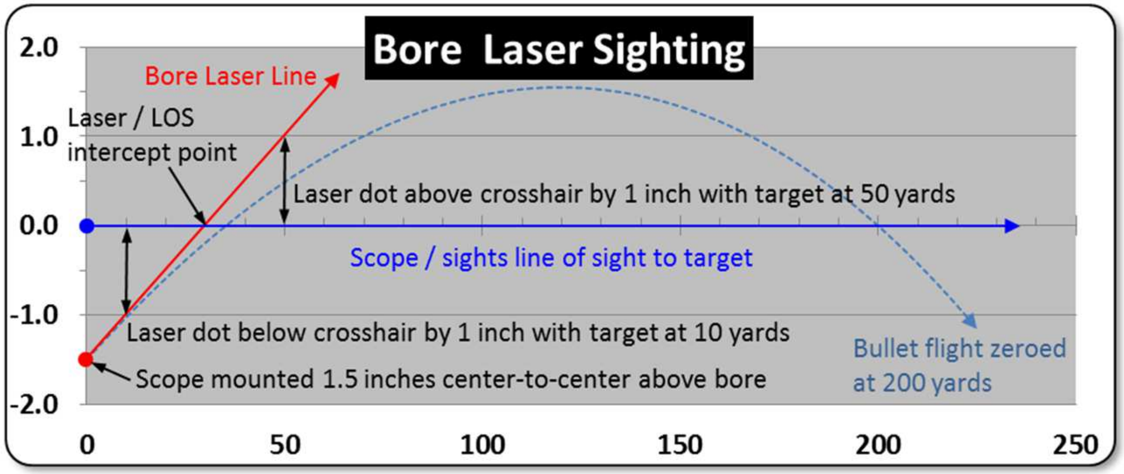
The laser bore sight solution displays the two key numbers required to sight-in a firearm at a desired zero distance when using a bore laser light such as the *SITELITE® Mag Laser Boresighters ®.*

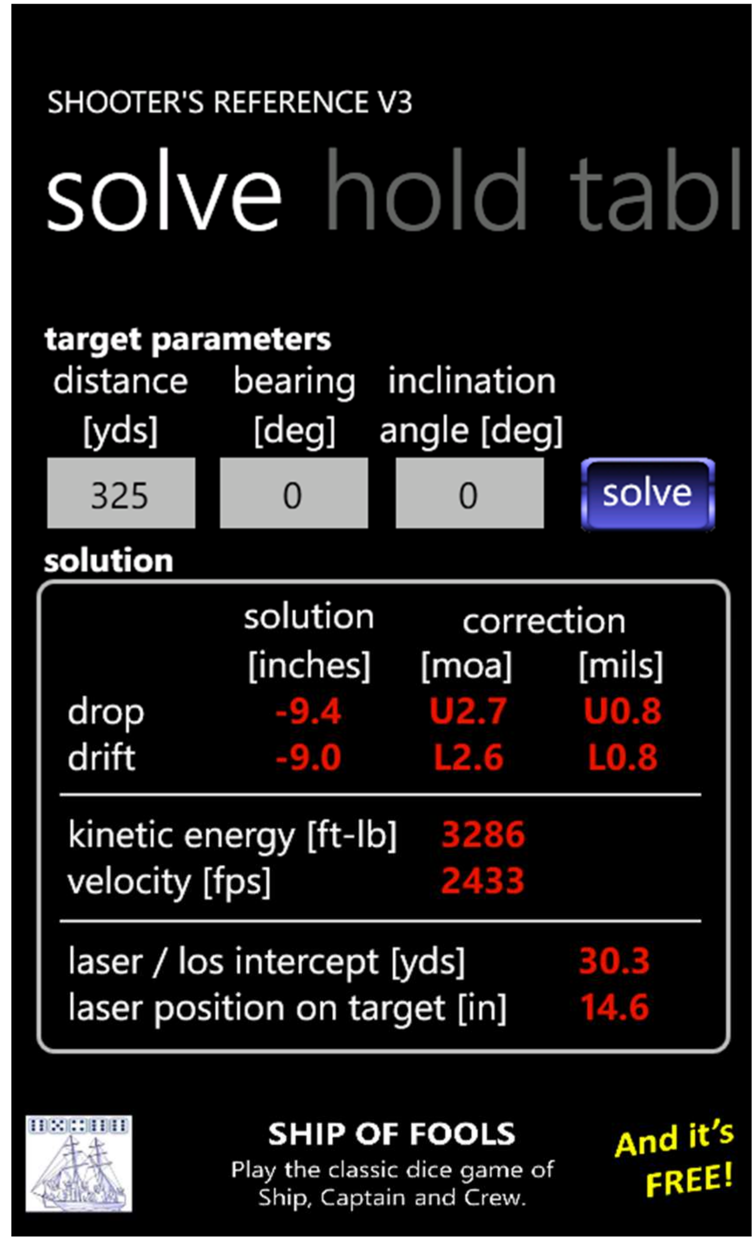
The laser / LOS intercept is the distance at which the bore laser line and the line of sight cross. It is displayed in yards or meters. If you place a target at this distance, the laser dot on the target should be right in the center of the scope or on the front sight.



solve [enter target data and solve model]

The laser position on target is the distance from the sight position to the laser dot on the target required to achieve the desired zero distance. The target distance is the value entered for distance under target parameters.





Tip: *In addition to the target distance, the bore sight calculator requires the ballistics of the cartridge in use and the mounting height of the scope or sights. The cartridge ballistic specs can be manually entered in the setup page or by selecting a cartridge in the search page. Consult your laser bore sight manufacturer's user's manual for instructions specific to your model.*

hold [sight picture]

Mil-Dot Sight Picture

Once a solution is found, the **hold** page displays the "hold" position required to be on target at the distance, bearing, and inclination angle entered on the **solve** page. Holding the firearm such that the target is in the position indicated by the green dot, will place the shot on the target.

The vertical axis is labeled in half mil-dot increments with the on-target distances corresponding to that vertical hold. The horizontal axis is also labeled in half mil-dot increments with the distances corresponding to wind drift.

For example, a 350 yard shot would require a vertical hold of just under 1 mil (352 yards) for drop and about 0.7 mils (0.7 x 500 yards) for wind drift.

When metric units are selected, sight picture values are displayed in meters.

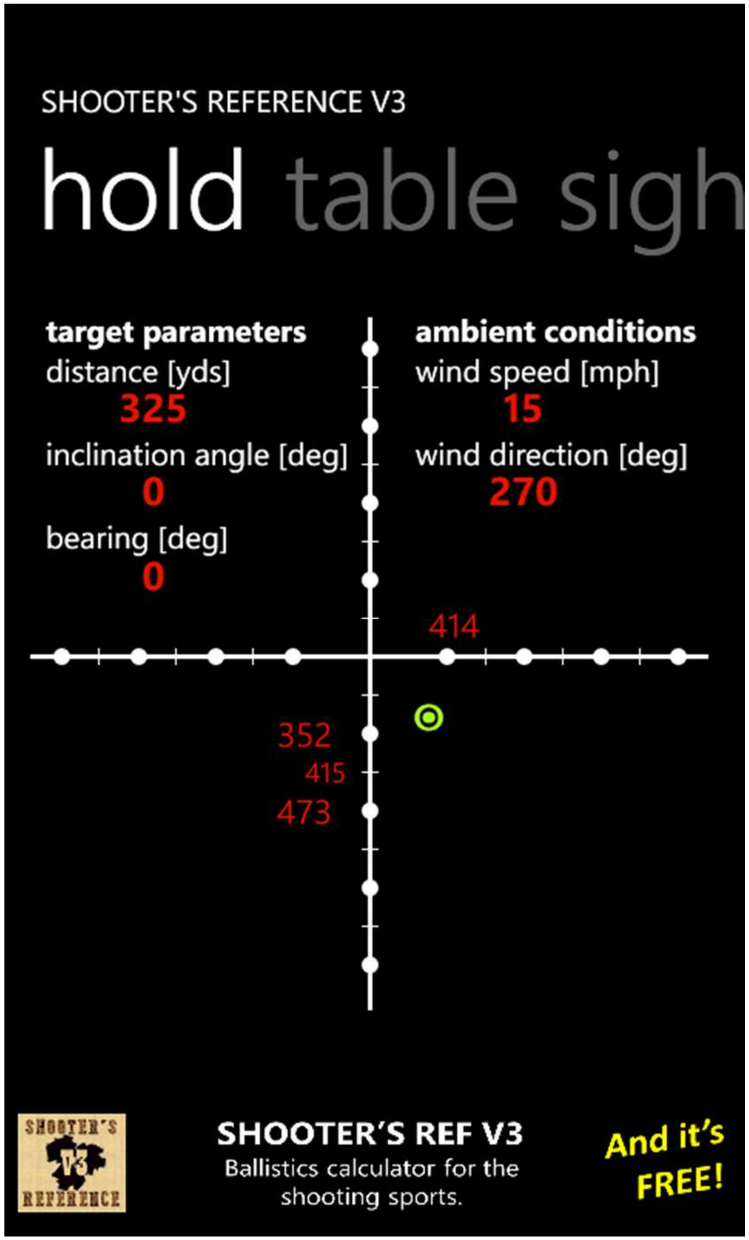
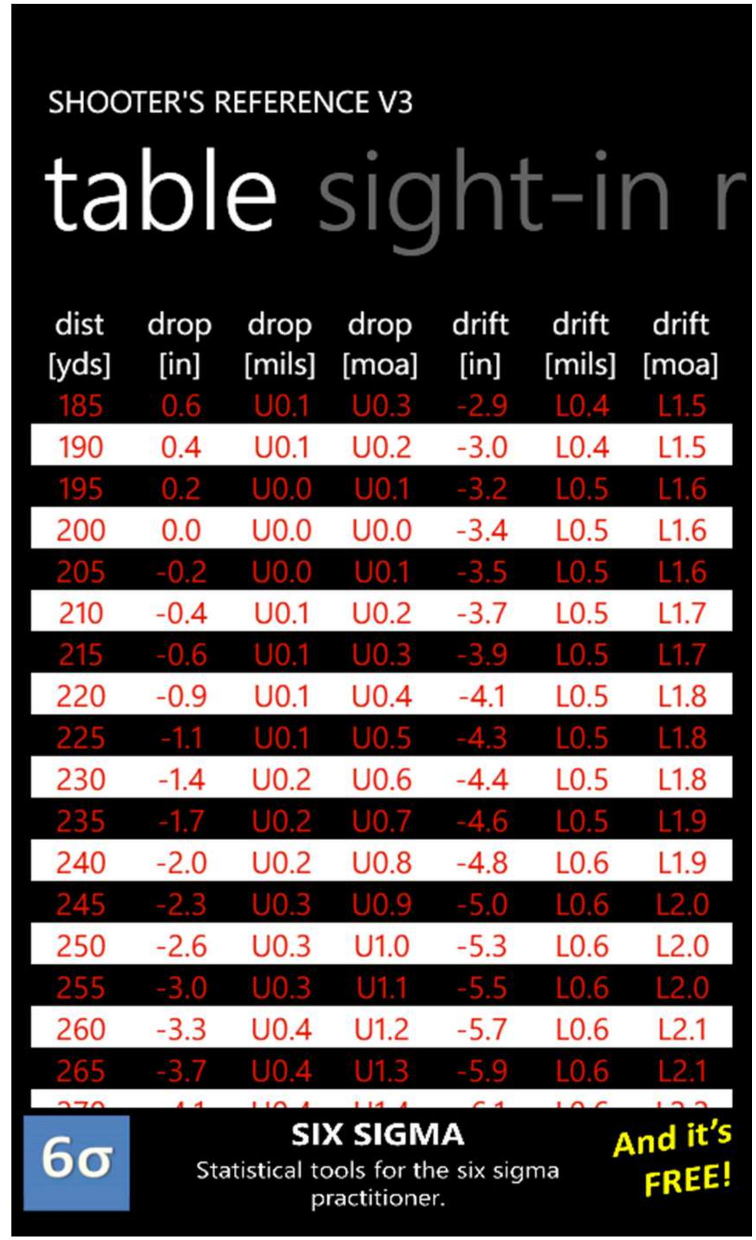


table [view drop and drift correction table]

Drop and Drift Table

Once a solution is found, the **table** page displays the drop and drift solution from 50 to 500 yards or meters at 5 yard or meter increments at a zero degree inclination angle.

“U” and “D” preceding a number refer to up and down while “L” and “R” preceding a number refer to left and right sight adjustments.



dist [yds]	drop [in]	drop [mils]	drop [moa]	drift [in]	drift [mils]	drift [moa]
185	0.6	U0.1	U0.3	-2.9	L0.4	L1.5
190	0.4	U0.1	U0.2	-3.0	L0.4	L1.5
195	0.2	U0.0	U0.1	-3.2	L0.5	L1.6
200	0.0	U0.0	U0.0	-3.4	L0.5	L1.6
205	-0.2	U0.0	U0.1	-3.5	L0.5	L1.6
210	-0.4	U0.1	U0.2	-3.7	L0.5	L1.7
215	-0.6	U0.1	U0.3	-3.9	L0.5	L1.7
220	-0.9	U0.1	U0.4	-4.1	L0.5	L1.8
225	-1.1	U0.1	U0.5	-4.3	L0.5	L1.8
230	-1.4	U0.2	U0.6	-4.4	L0.5	L1.8
235	-1.7	U0.2	U0.7	-4.6	L0.5	L1.9
240	-2.0	U0.2	U0.8	-4.8	L0.6	L1.9
245	-2.3	U0.3	U0.9	-5.0	L0.6	L2.0
250	-2.6	U0.3	U1.0	-5.3	L0.6	L2.0
255	-3.0	U0.3	U1.1	-5.5	L0.6	L2.0
260	-3.3	U0.4	U1.2	-5.7	L0.6	L2.1
265	-3.7	U0.4	U1.3	-5.9	L0.6	L2.1

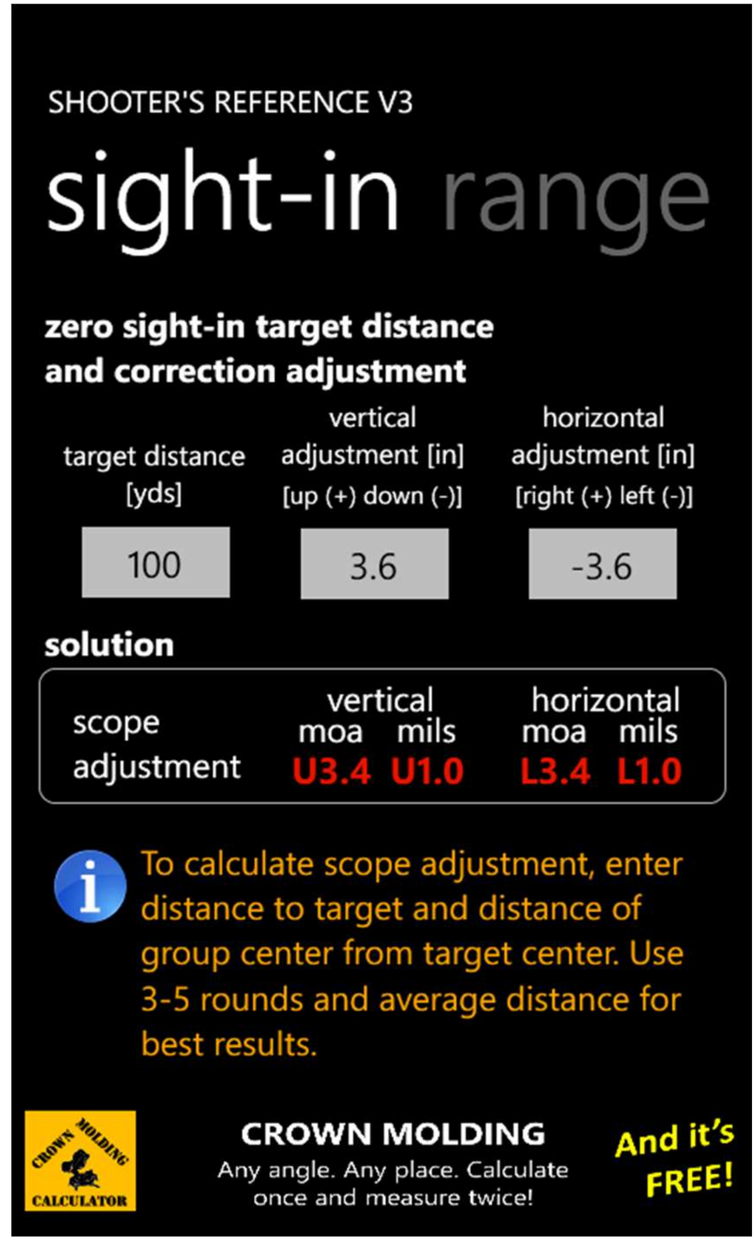
sight-in [sight-in your rifle at the range]

Sighting-in on the Range

The **sight-in** page provides a simple, non-model method of zeroing a firearm on the range.

- **target distance**
  - Required, in yards or meters
- **vertical adjustment**
  - Required, in inches or centimeters
  - The vertical distance to move the impact point. Enter a positive value to move the impact point up, a negative value to move the impact point down.
- **horizontal adjustment**
  - Required, in inches or centimeters
  - The horizontal distance to move the impact point. Enter a positive value to move the impact point right, a negative value to move the impact point left.

> ***Tip**: Use 3-5 rounds and average the distance from the target center for best results.*

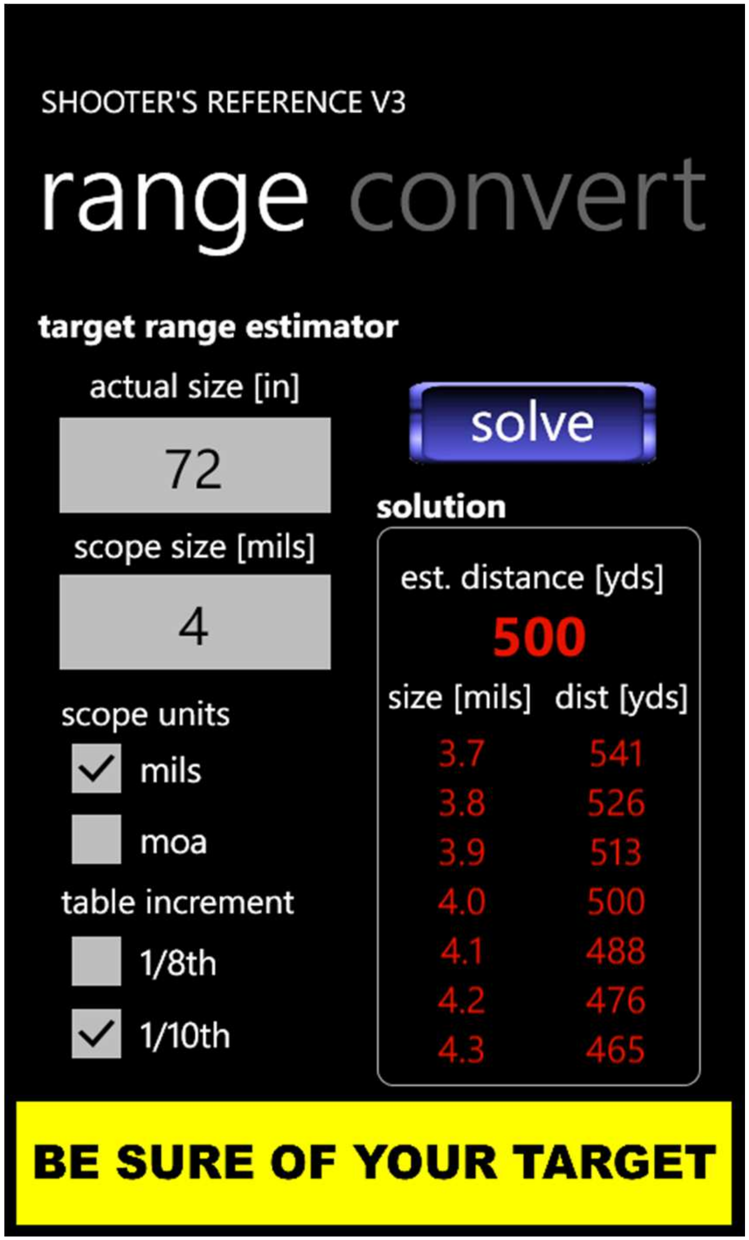


range [estimate target range using mil scope]

Estimating Range Using a Mil/MOA Scope

The **range** page provides a simple method of estimating the range of a target given its actual size and apparent size in mils or MOA.

- **actual size**
  - Required, in inches or centimeters
  - The actual height of the target area being measured
- **scope size**
  - Required, in mils or MOA
  - The apparent height of the target area being measured
- **scope units**
  - Required, choose mils or MOA
  - Determines table increment display
- **table increment**
  - Required, choose 1/8th or 1/10th increments
  - Determines range table increment display



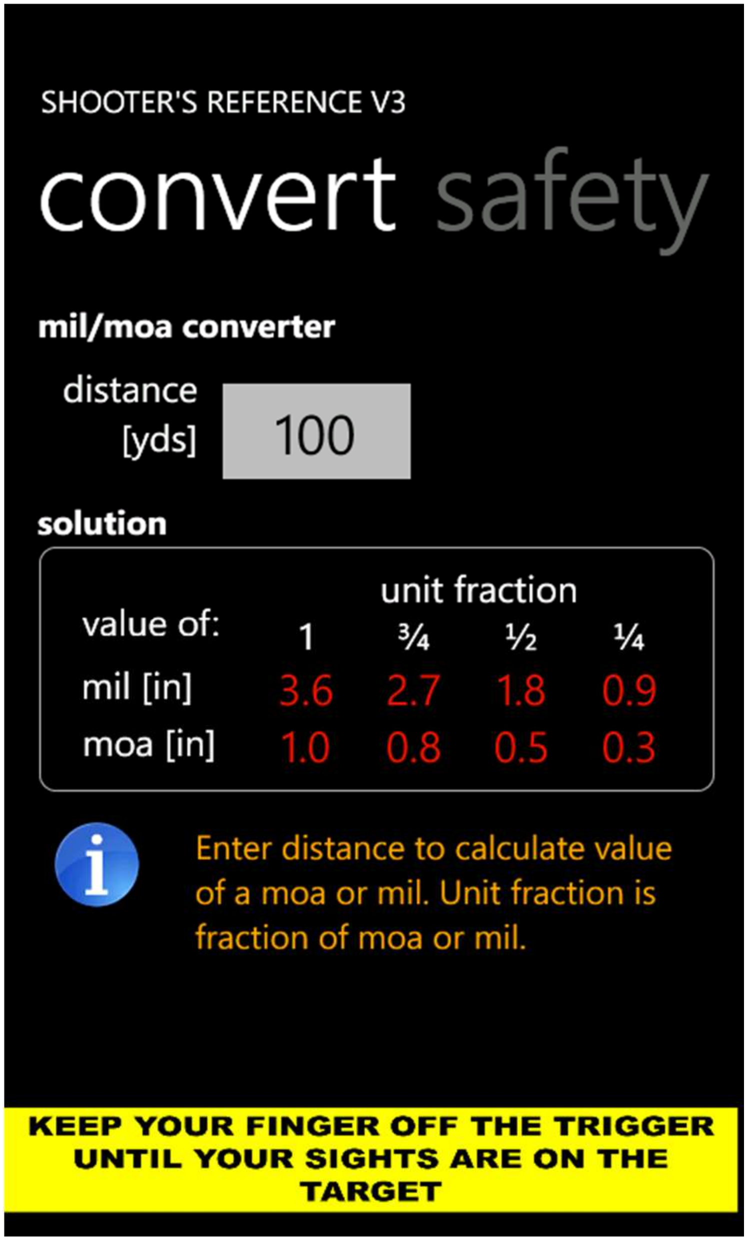
convert [convert distances to mils and moa]

Converting Mils or MOA

The **convert** page provides a simple calculator to determine the value of Mils or MOA’s at a given distance.

- **distance**
  - Required, in yards or meters
  - The target distance

The value of both a Mil and MOA (or quarter fractions) is displayed in inches or centimeters.

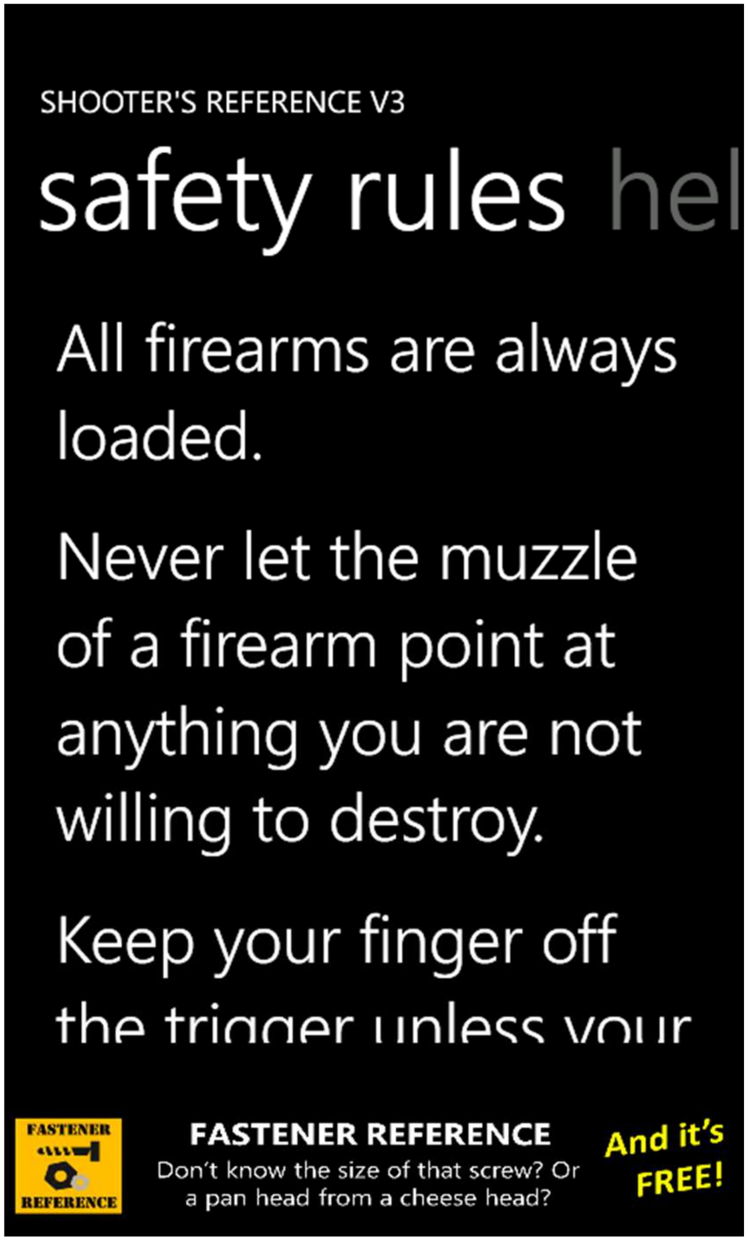


safety rules [read them. learn them. live them.]

Lt. Col. Jeff Cooper (USMC), founder of Gunsite Academy, author, columnist, professor, WW II and Korean War combat veteran, and innovator of the Modern Technique of the Pistol had four simple safety rules:

- **ALL FIREARMS ARE ALWAYS LOADED**
- **NEVER LET THE MUZZLE OF A FIREARM POINT ANYTHING YOU ARE NOT WILLING TO DESTROY**
- **KEEP YOUR FINGER OFF THE TRIGGER UNTIL YOUR SIGHTS ARE ON THE TARGET**
- **BE SURE OF YOUR TARGET**

THE IMPORTANCE OF THESE RULES CAN NOT BE STRESSED ENOUGH. THE MOST IMPORTANT SAFETY FEATURE WHEN HANDLING A FIREARM IS THE ONE BETWEEN YOUR EARS, NOT THE ONES ON THE FIREARM.



APPENDIX

- Model internals
- Model performance

model internals [how it works]

Shooter's Reference's ballistics model is based on Newtonian physics. This section describes the inner workings of the model in mathematical terms. Basic knowledge of physics and calculus is required to understand the model but is not a prerequisite for using the application. Several good books available as well as Wikipedia's articles on external ballistics and related topics as well as many other Internet sources. Our preferred source is Bryan Litz's excellent book.

Litz, Bryan (2011), *Applied Ballistics for Long Range Shooting* (2nd edition), Cedar Springs, MI, Applied Ballistics LLC.

The ballistics model can be divided into three functional blocks.

- Ambient Conditions
- Firearm Setup
- Projectile Motion Simulation

Ambient Conditions

There are three factors that are important to calculating an accurate trajectory: air density, the speed of sound, and crosswind speed.

Air density can be calculated one of two ways by the model. The preferred method is to use temperature, pressure and humidity at the shooter's location. Alternatively, the model can use elevation and sea level temperature, pressure and humidity or their approximation. In reality, for hunting distances out to 500 yards, air density is a very small factor in bullet drop or drift, typically on the order of tenths of an inch. By comparison, we see several inches of variation when comparing trajectories generated by utilizing the G7 model instead of the G1+BC model (see comparisons in Appendix).

model internals [how it works]

To determine air density from temperature, pressure and humidity we employ the following equations:

First, we calculate the saturation pressure for water vapor from a rather complicated magical formula that uses temperature only.

$$p_{sat} = e^{\left(\frac{\frac{77.435+0.0057-\frac{7235}{T}}{T}}{T^{8.2}}\right)}$$

Next, we calculate the partial pressure of the water vapor from the relative humidity and the saturation pressure. This is a very small number, on the order of 1-2% of the total atmospheric pressure.

$$p_{wv} = \left(\frac{RH}{100}\right) \times p_{sat}$$

Before we calculate the partial pressure of dry air, we need to know the local atmospheric pressure. This can be measured directly or obtained from your favorite weather website.

If the local atmospheric pressure can not be determined, an approximation can be made based on altitude and either actual nearby or standard sea level pressure.

$$p = p_0 e^{-\left(\frac{h}{h_0}\right)}$$

The partial pressure of dry air can be determined by simple subtraction:

$$p_{dry} = p - p_{wv}$$

The density of a mixture of dry air and water follows:

$$\rho_{humid} = \frac{p_{dry} \times M_{dry} + p_{wv} \times M_{wv}}{R \times T}$$

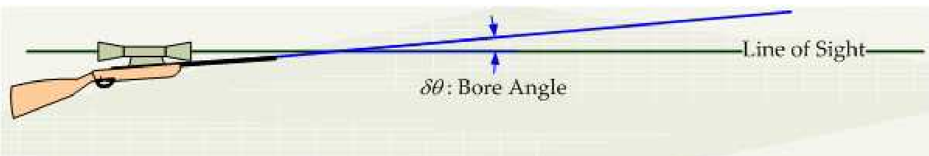
The speed of sound varies with air density and is given by:

$$c = \sqrt{\gamma \times \frac{p}{\rho_{humid}}}$$

model internals [how it works]

Firearm Setup

Bore angle is the barrel cant that results from the difference between the line of sight to the target (what you see through the scope or sights) and the launch angle required to be on target at the zero distance on flat ground. Shooter's Reference allows the user to choose an arbitrary zero distance.

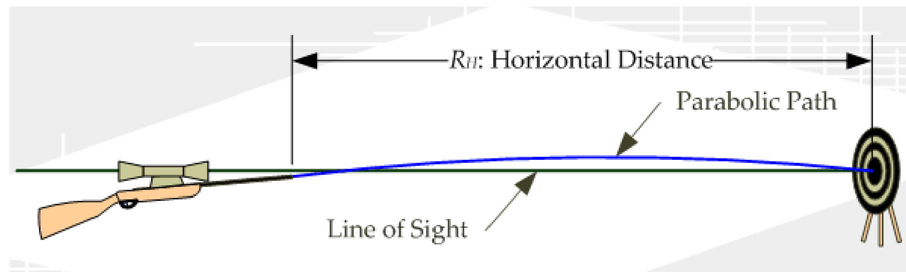


Angle Exaggerated For Illustration Purposes
Source: http://en.wikipedia.org/wiki/Rifleman's_rule

Most manufacturers' ballistics tables assume a height of 1.5 inches but chances are that your sights or scope are not mounted at that height. This is a significant source of error. The centerline to centerline height of the sights or scope above the barrel is required to calculate the bore angle. This measurement is critical and should be taken with care.

A zero distance that is close to the target range is recommended. For example, when targets are likely to be around 75 yards away, set the zero distance to 75 yards.

Bore angles are typically very small, around 0.05 to 0.10 degrees. However, a small variation can result in several inches of error at 500 yards. Shooter's Reference calculated zero at the actual zero distance is ±0.05 inches (±1.27mm).



Angles Exaggerated for Illustration
Source: http://en.wikipedia.org/wiki/Rifleman's_rule

The zero distance and scope height entered on the **setup** page is used to generate a custom drop table for your cartridge and firearm. The ballistics model uses an iterative process that takes into account the cartridge, bullet and ambient conditions to determine the bore angle.

model internals [how it works]

The zero correction in mils and moa is displayed on the **solve** page and the bore angle is used by the ballistics model along with the inclination angle to generate the solution at the target distance as well as the custom drop table.

Projectile Motion Simulation

Once the ambient conditions, firearm, and cartridge/bullet parameters are set, the ballistics model generates a solution at the user specified distance on the **solve** page and for each distance point in the accompanying drop/drift **table** page.

Bullet drag is calculated using one of two formulas depending on whether the user has selected the "use BC" option on the **setup** page. It is recommended that the "use BC" option is not used and that instead a bullet model that most closely matches the bullet in use be chosen. BC's are not constant with speed although manufacturers quote a single BC, typically based on the G1 model in their cartridge specifications.

Using the manufacturer's BC introduces a systemic error and results in larger errors. The Appendix shows model results for three common cartridges with and without BC compensation. For modern low drag bullets, the G7 model without BC compensation provides the best results.

The ballistics model implements a table of drag coefficients for each of the supported bullet models developed by the Army Ballistics Research Lab. These are discussed in the **bullet models** section. A new drag is calculated for each trajectory point based on the bullet's velocity at that point.

The two equations for calculating drag are:

$$F_{drag} = \frac{\rho \times v^2 \times C_{drag} \times A}{2}$$

$$C_{drag} = \frac{C_{G1CD} \times m}{BC \times D^2} \qquad \text{[If BC is used]}$$

model internals [how it works]

The ballistics model simulates the path of the projectile, or bullet, by repeatedly calculating its drag, velocity, acceleration, and position at intervals of either 0.5 yards or meters depending on whether Imperial or metric units are selected.

The initial conditions are determined by the muzzle velocity and the launch angle. The launch angle is determined by the inclination angle to the target and the bore angle of the "zeroed" firearm.

The model performs calculations based on units of time, t, required to travel the model distance interval.

$$dt = \frac{dx}{v_{x(0)}}$$

The initial velocity is the muzzle velocity.

$$v_{(0)} = v_{muzzle}$$

Since the projectile is launched at an angle (at a minimum the bore angle on flat ground), it is necessary to determine its velocity in both the x and y axes. In addition, the forces of gravity and drag act differently in both axes so those must also be treated separately.

The initial velocities in the x and y axes are given by:

$$v_{x(0)} = v_{(0)} \times \cos(\theta + \delta)$$

$$v_{y(0)} = v_{(0)} \times \sin(\theta + \delta)$$

Acceleration is given by the general vector formula:

$$\vec{a} = \frac{\vec{F}}{m}$$

Acceleration (deceleration in this case) can be approximated as follows for each axis:

$$a_x = -\frac{F_{drag}}{m} \quad \text{and} \quad a_y = -G + \frac{F_{drag}}{m}$$

model internals [how it works]

Given velocity, acceleration and time, a new position can be calculated.

$$x_{(t+1)} = x_{(t)} + v_{x(t)} \times dt + \frac{a_x}{2} \times dt^2$$

$$y_{(t+1)} = y_{(t)} + v_{y(t)} \times dt + \frac{a_y}{2} \times dt^2$$

New velocities are similarly updated.

$$v_{x(t+1)} = v_{x(t)} + a_x \times dt$$

$$v_{y(t+1)} = v_{y(t)} + a_y \times dt$$

$$v_{(t+1)} = \sqrt{{v_{x(t+1)}}^2 + {v_{y(t+1)}}^2}$$

Since the projectile is now moving more slowly, the time to travel to the next computation point also needs to be recalculated..

$$dt = \frac{dx}{v_{x(t+1)}}$$

The process repeats until the drop and drift table is completed and the target distance reached.

Wind Drift

Wind drift is calculate using the Army Ballistics Lab method described in: Leupold, Herbert A. (October 1996), *Wind Drift of Projectiles: A Ballistics Tutorial*, ARL-TR-1124.

The full text may be downloaded from:

http://www.dtic.mil/dtic/tr/fulltext/u2/a317305.pdf

The amount of drift requires the calculation of the perpendicular wind speed, the actual time of flight, and the time of flight in a vacuum. The time of flight in a vacuum is simply the time to travel the horizontal distance at the muzzle velocity since there is no drag to slow the projectile’s velocity while in flight.

$$t_v = \frac{x_h}{v_0}$$

The wind drift is calculated with the following equation:

$$x_d = v_w \times (t_a - t_v)$$

model internals [how it works]

Kinetic Energy

Kinetic energy is calculated at the target range. While kinetic energy is a good indicator of a bullet's ability to stop and/or kill game, it is not the only factor. The user of this program should consult the manufacturer's recommendations for specific game. A small bullet with high kinetic energy does not perform the same as a large bullet with the same kinetic energy.

Kinetic energy is calculated as follows:

$$E_k = \frac{m \times v^2}{2}$$

model internals [how it works]

VARIABLE	DESCRIPTION
T	temperature
RH	relative humidity
p	barometric pressure
p_0	sea level barometric pressure
p_{sat}	vapor saturation pressure
p_{wv}	partial pressure of water vapor
p_{dry}	partial pressure of dry air
ρ_{humid}	density of humid air
v_w	perpendicular (cross) wind speed
h	elevation
h_0	height of the atmosphere
c	speed of sound
R	universal gas constant
M_{wv}	molar mass of water vapor
M_{dry}	molar mass of dry air
γ	adiabatic index

VARIABLE	DESCRIPTION
dx	calculation interval distance
dt	calculation interval time
$\vec{F}$	force vector
m	mass
$\vec{a}$	acceleration vector
D	diameter of bullet
F_{drag}	drag force
C_{drag}	drag coefficient
C_{G1CD}	drag coefficient of G1 std. model
a_x, a_y	acceleration at time t in x or y
$v_{(t)}$	velocity at time t
$v_{x(t)}$, $v_{y(t)}$	velocity at time t in x or y
$x_{(t)}$, $y_{(t)}$	position at time t
x_h	horizontal distance
t_v	time of flight in a vacuum
t_a	actual time of flight

model internals [how it works]

Standard Bullet Models

Shooter's Reference allows the user to select various standard models that are used to calculate bullet drag. By choosing the model that best fits your bullet, you can improved the accuracy of the results. Shooter's Reference continuously adjusts drag based on the instantaneous velocity of the bullet based on the selected bullet shape model.

The descriptions of the bullet models in the table to the right refer to the terms "blunt ogive" "secant ogive" with and "tangent ogive." These describe the shape of the bullet's nose and date back to nose cone designs for rockets.

More information on nose cone designs is available on Wikipedia:

http://en.wikipedia.org/wiki/Nose_cone_design

MODEL	DESCRIPTION
G1	Ingalls. Flatbase. 2 caliber blunt ogive nose. Generally used by manufactures to express BC.
G2	Aberdeen J projectile.
G5	Short 7.5° boat-tail. 6.19 caliber tangent ogive nose.
G6	Flatbase. 6 caliber secant ogive nose.
G7 Default Model	Long 7.5° boat-tail. 10 caliber tangent ogive nose. Best model for low drag bullets. Some manufacturers provide G7 BC's in addition to G1 BC's.
G8	Flatbase. 10 caliber secant ogive nose.
GL	Blunt lead nose.

Source: http://en.wikipedia.org/wiki/External_ballistics

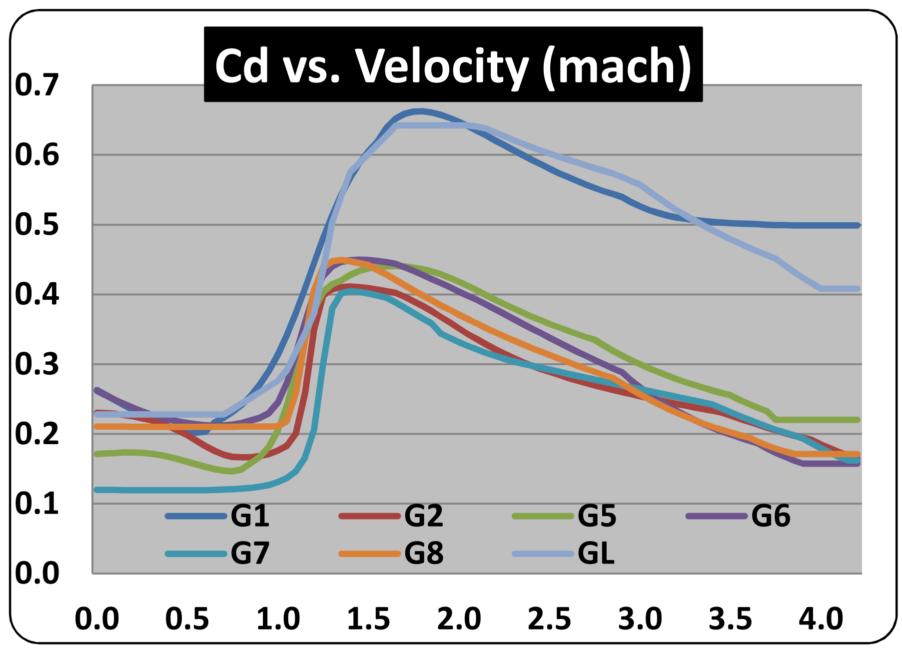
model internals [how it works]

Manufacturers typically provide a BC (ballistics coefficient) that is based on the G1 model. Some have also started providing G7 based BC's. However, best results are achieved without using BC compensation because BC's vary with velocity.

The G1 and GL models will yield very similar results, typically within 0.5 inches (1.3 cm) of drop at 500 yards (457m). The G2, G5, G6, G7, and G8 models also yield similar results. Since most long range shooters are using very low drag boat-tails for best performance, the G7 model yields the best results.

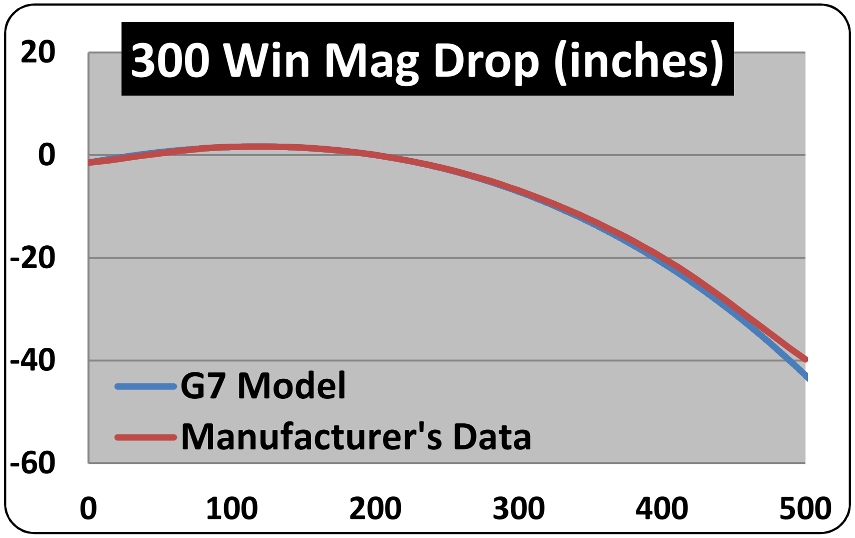
Results of comparisons of manufacturer's data compared with the model solutions, with and without BC compensation are provided for the Winchester 308, Winchester 338 Lapua Magnum and the Winchester 300 Magnum.

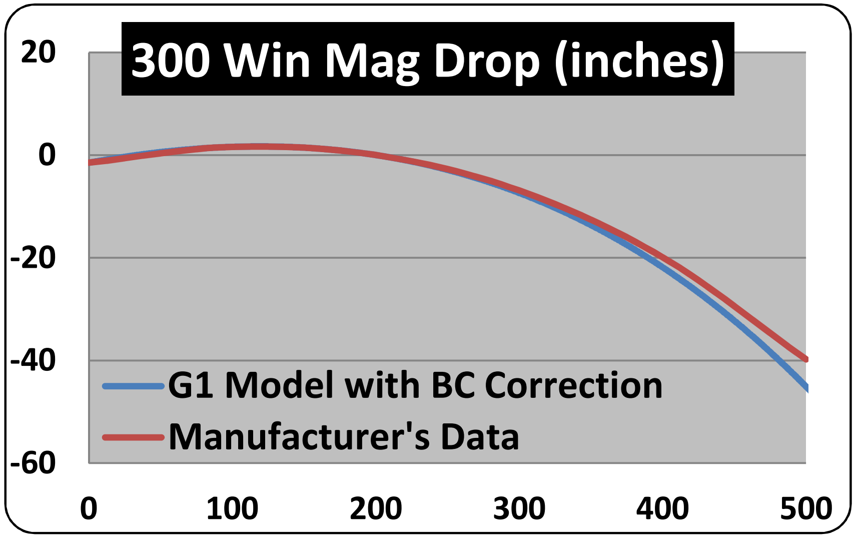
Bullet Shape and Recommended Model



model performance data [300 winchester magnum]

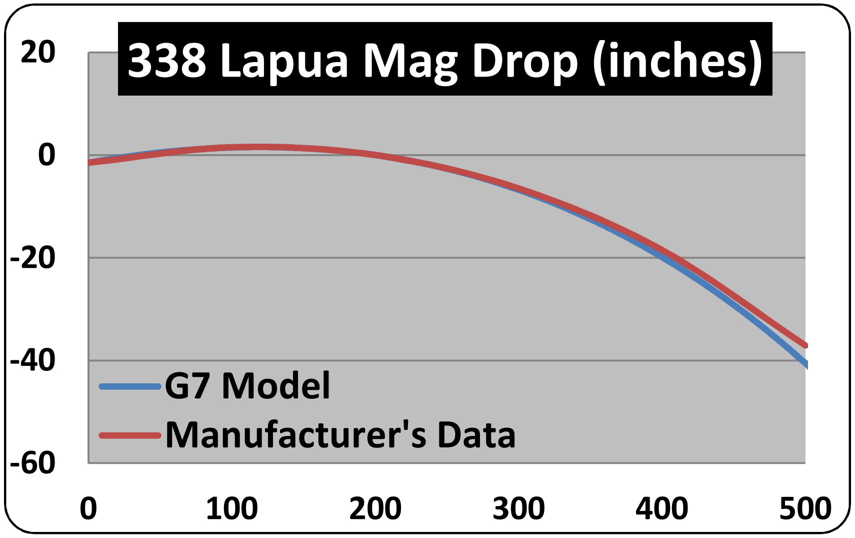
300 Win Mag (Winchester GM300WM) -Manufacturer's Data vs. Shooter's Ref Model								
Distance (yds)		0	100	200	300	400	500	Δ @ 500
V (fps)	Manufacturer	2900	2726	2558	2396	2240	2090	
	SR Model G7	2900	2730	2566	2406	2249	2093	3
	SR Model G1 + BC	2900	2710	2526	2348	2178	2018	-72
E (ft-lbs)	Manufacturer	3548	3134	2760	2422	2117	1843	
	SR Model G7	3548	3145	2777	2441	2133	1847	4
	SR Model G1 + BC	3548	3097	2691	2325	2001	1718	-125
D (in)	Manufacturer	-1.5	1.6	0.0	-6.9	-19.9	-39.8	
	SR Model G7	-1.5	1.6	0.0	-7.1	-20.8	-42.7	-2.9
	SR Model G1 + BC	-1.5	1.6	0.0	-7.3	-21.8	-44.9	-5.1
W (in)	Manufacturer	0.0	0.6	2.4	5.5	10.1	16.4	
	SR Model G7	0.0	0.7	2.4	5.4	9.9	16.0	-0.4
	SR Model G1 + BC	0.0	0.7	2.7	6.2	11.3	18.2	1.8

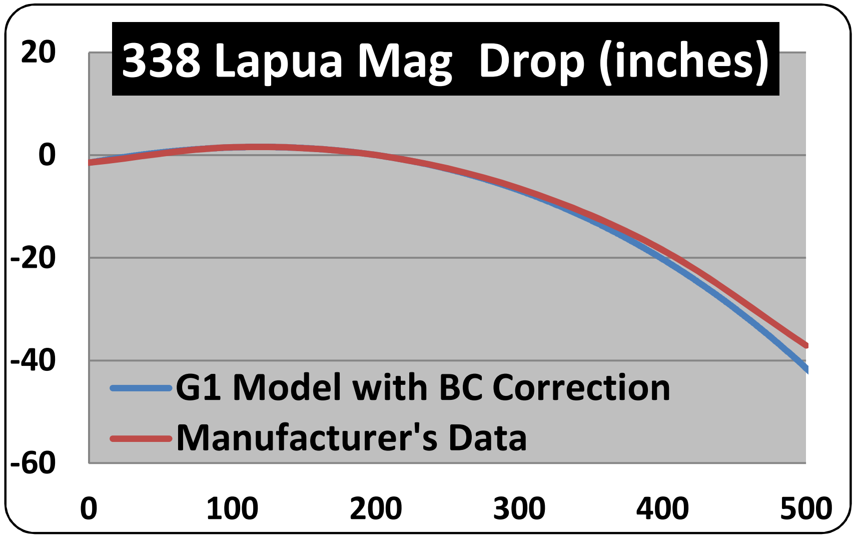




model performance data [338 winchester lapua magnum]

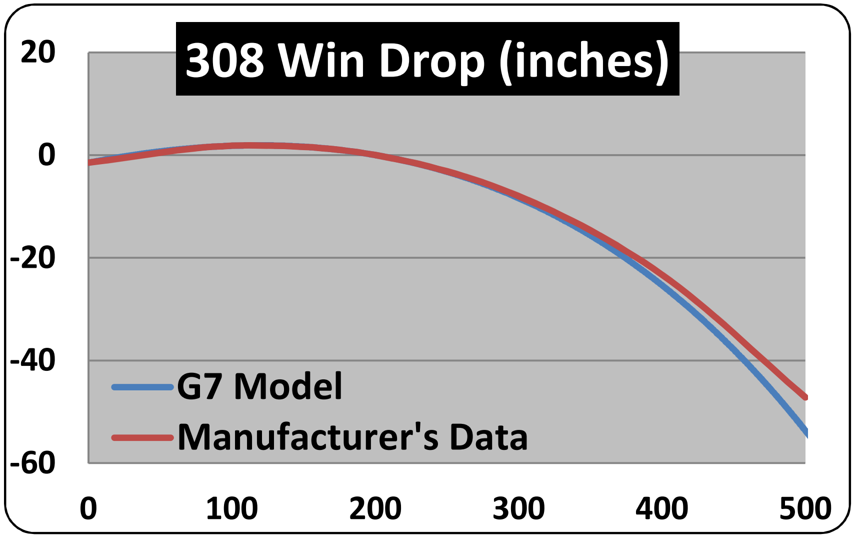
338 Lapua Mag (Winchester GM338LM) - Manufacturer's Data vs. Shooter's Ref Model								
Distance (yds)		0	100	200	300	400	500	Δ @ 500
V (fps)	Manufacturer	2950	2789	2634	2484	2339	2199	
	SR Model G7	2950	2785	2625	2469	2316	2166	-33
	SR Model G1 + BC	2950	2775	2606	2441	2282	2130	-69
E (ft-lbs)	Manufacturer	4830	4318	3851	3426	3037	2685	
	SR Model G7	4830	4305	3824	3382	2977	2603	-82
	SR Model G1 + BC	4830	4275	3768	3307	2890	2519	-166
D (in)	Manufacturer	-1.5	1.5	0.0	-6.5	-18.5	-37.1	
	SR Model G7	-1.5	1.5	0.0	-6.7	-19.8	-40.4	-3.3
	SR Model G1 + BC	-1.5	1.5	0.0	-6.8	-20.2	-41.4	-4.3
W (in)	Manufacturer	0.0	0.5	2.1	4.9	8.8	14.3	
	SR Model G7	0.0	0.6	2.2	5.1	9.2	14.9	0.6
	SR Model G1 + BC	0.0	0.6	2.4	5.4	9.9	15.9	1.6

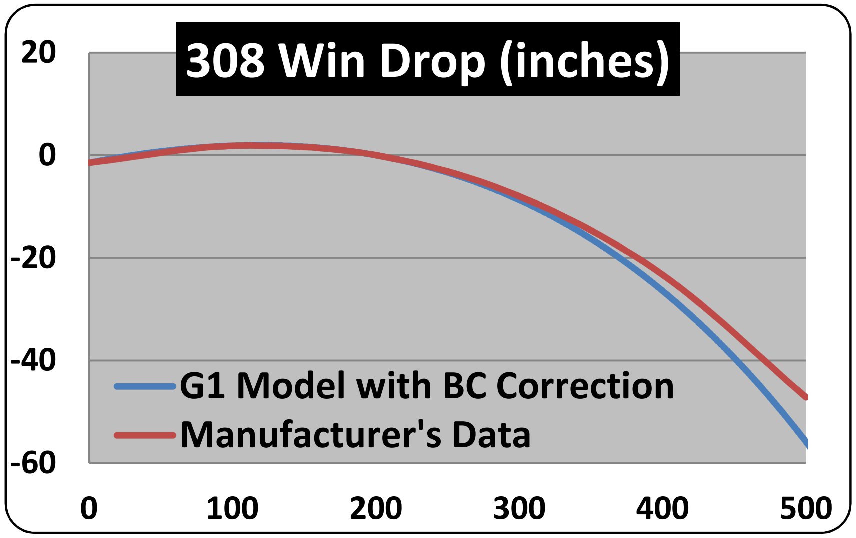




model performance data [308 winchester]

308 Win (Winchester AE308D) - Manufacturer's Data vs. Shooter's Ref Model								
Distance (yds)		**0**	**100**	**200**	**300**	**400**	**500**	**Δ @ 500**
V (fps)	**Manufacturer**	2820	2597	2385	2183	1990	1808	
	SR Model G7	2820	2598	2384	2175	1967	1767	-41
	SR Model G1 + BC	2820	2575	2342	2122	1921	1749	-59
E (ft-lbs)	**Manufacturer**	2648	2246	1894	1586	1319	1089	
	SR Model G7	2648	2248	1892	1576	1289	1040	-49
	SR Model G1 + BC	2648	2209	1826	1499	1229	1018	-71
D (in)	**Manufacturer**	-1.5	1.8	0.0	-8.0	-23.3	-47.2	
	SR Model G7	-1.5	1.8	0.0	-8.3	-25.2	-53.3	-6.1
	SR Model G1 + BC	-1.5	1.8	0.0	-8.7	-26.4	-55.8	-8.6
W (in)	**Manufacturer**	0.0	0.8	3.3	7.8	14.4	23.3	
	SR Model G7	0.0	0.9	3.4	7.8	14.5	24.0	0.7
	SR Model G1 + BC	0.0	0.9	3.7	8.6	16.1	26.2	2.9





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