



AFTS Basic Defensive Carbine

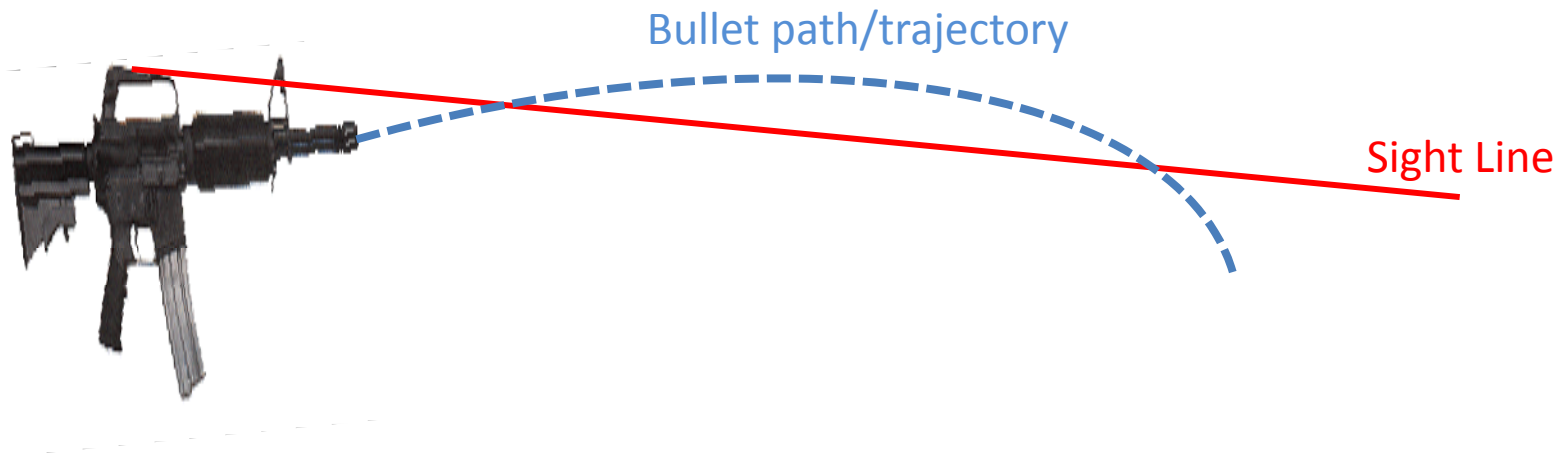
Chapter Four

Zero'ing your rifle and understanding holdovers

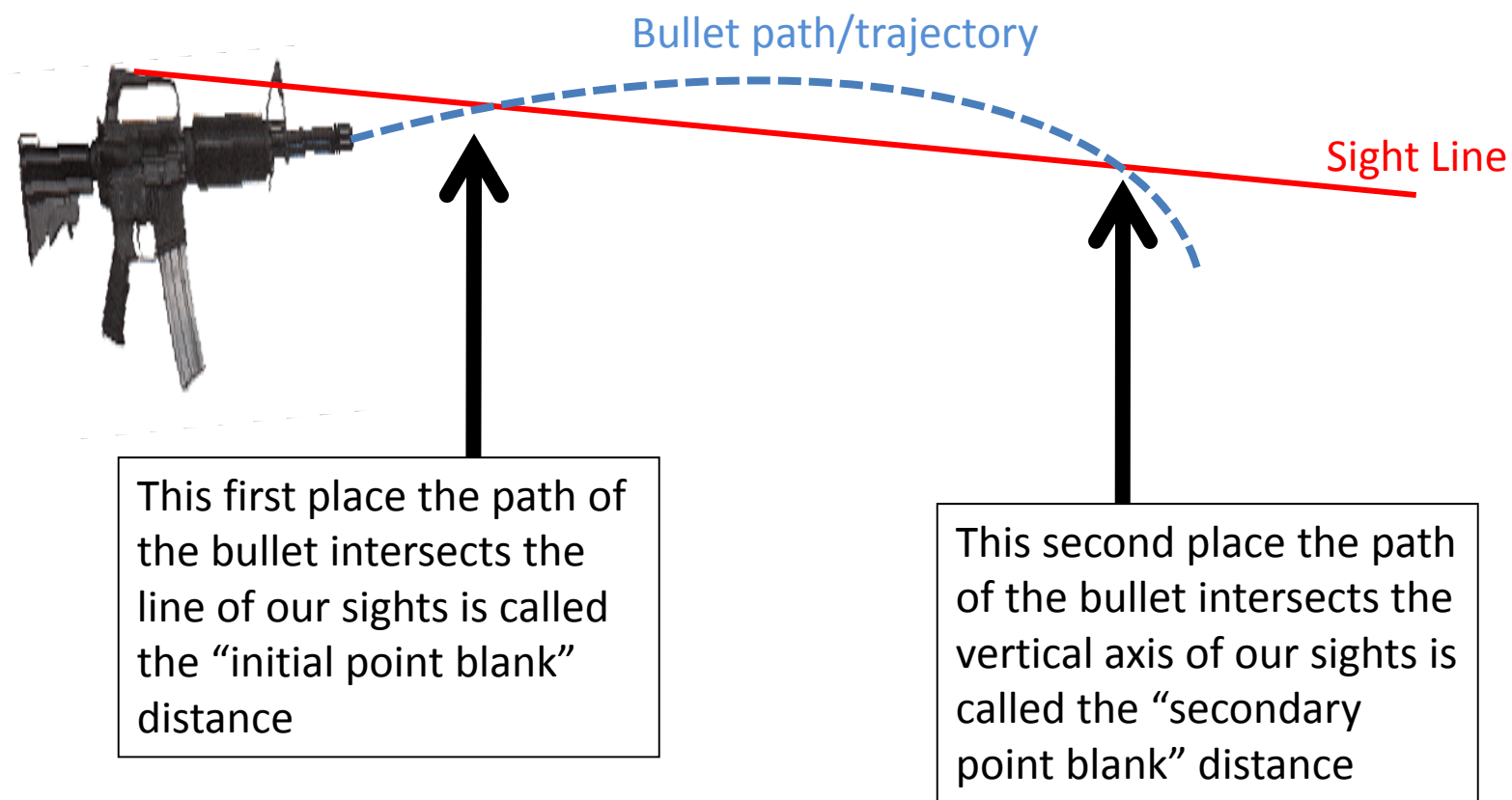
Bullet path/trajectory

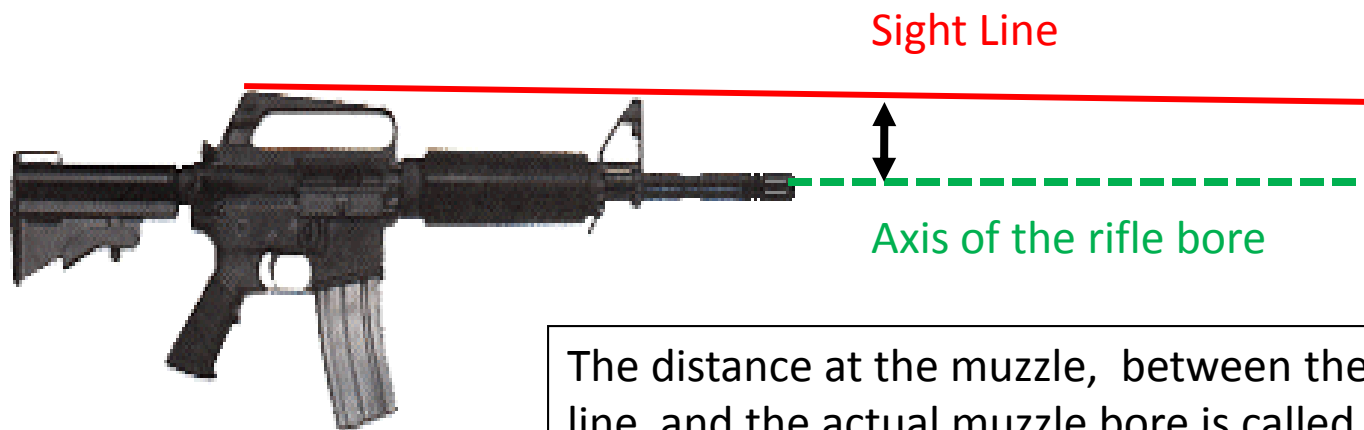


The instant the bullet leaves the muzzle of our rifle, gravity begins to act on it in the vertical axis pulling it down as it travels forward.....until finally at some point it intersects with the ground or your target....

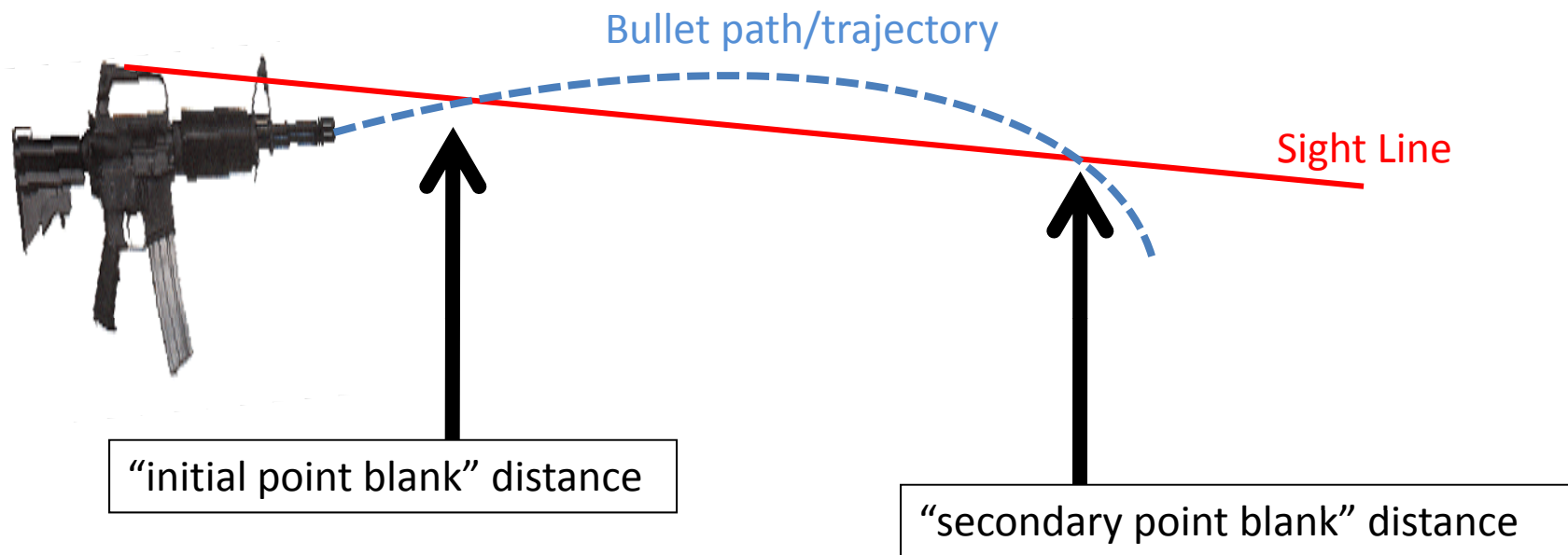


To make our sighting systems the most useful, we set them up at some vertical height above the bore axis of the rifle and effectively aim them downward at a steeper slope than the trajectory of the bullet so that the line of sight will in fact intersect that vertical path of the bullet twice during it's flight.....

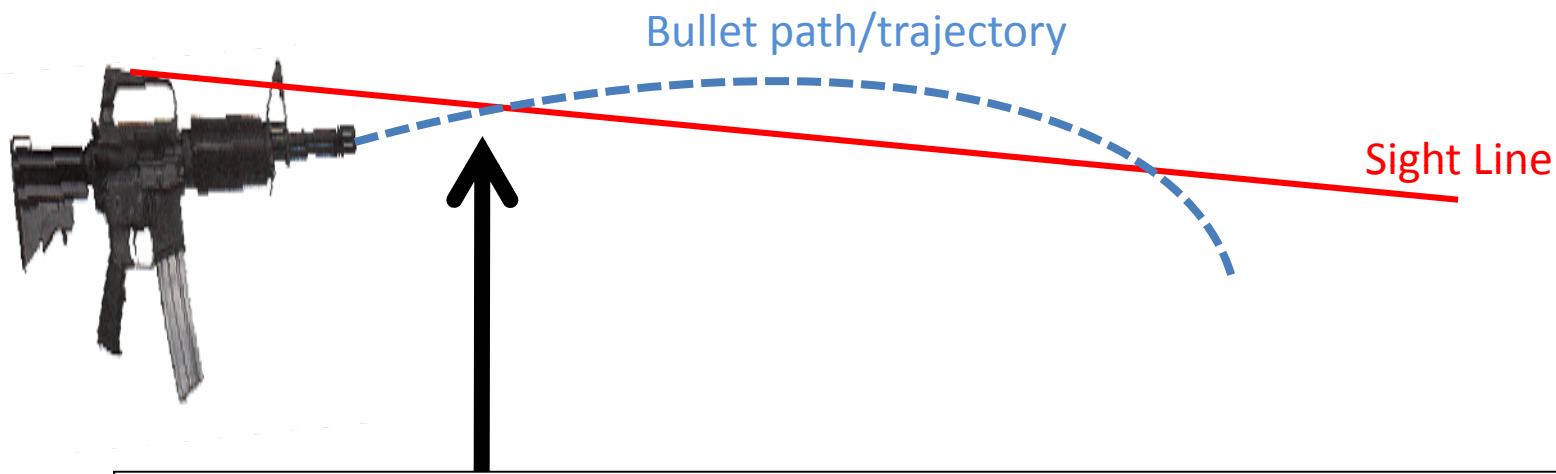




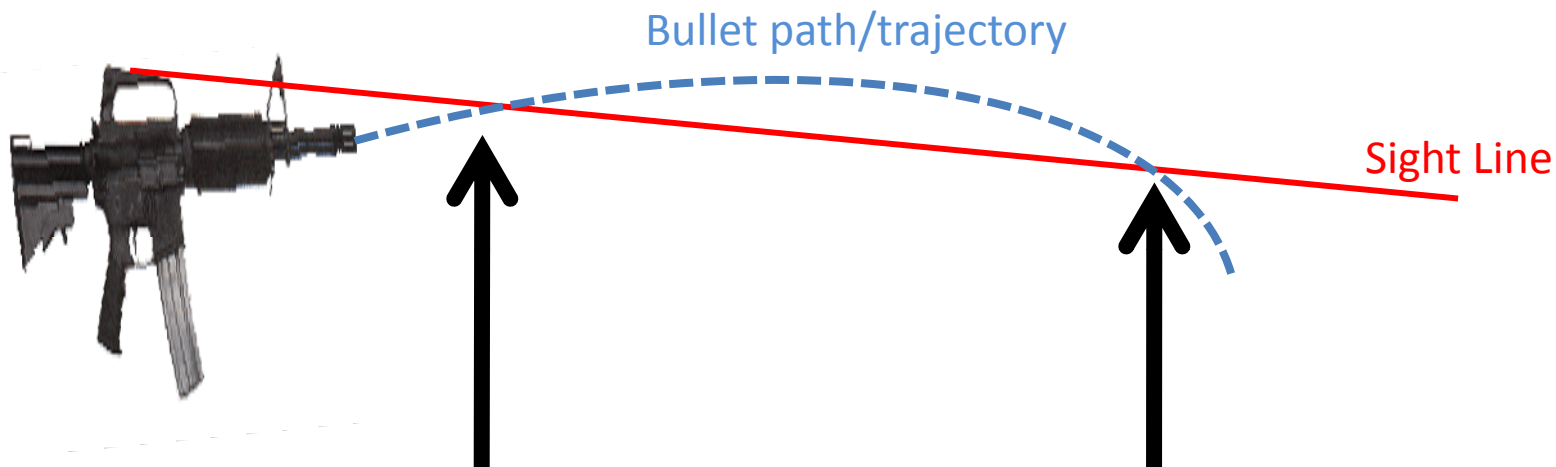
The distance at the muzzle, between the sight line and the actual muzzle bore is called **“height above bore”** and it tells us the vertical deviation between the line of sight and the path of the bullet as it exits the rifle’s barrel



When we zero our rifle, we adjust the vertical axis of the sight line to match either the initial or the secondary point blank point for our rifle at a specific distance....then when we aim the rifle we have to understand the ballistics and flight characteristics of our bullet's trajectory over the rest of the range of distances we might shoot at, so that we know where it is supposed to land at any specific distance....

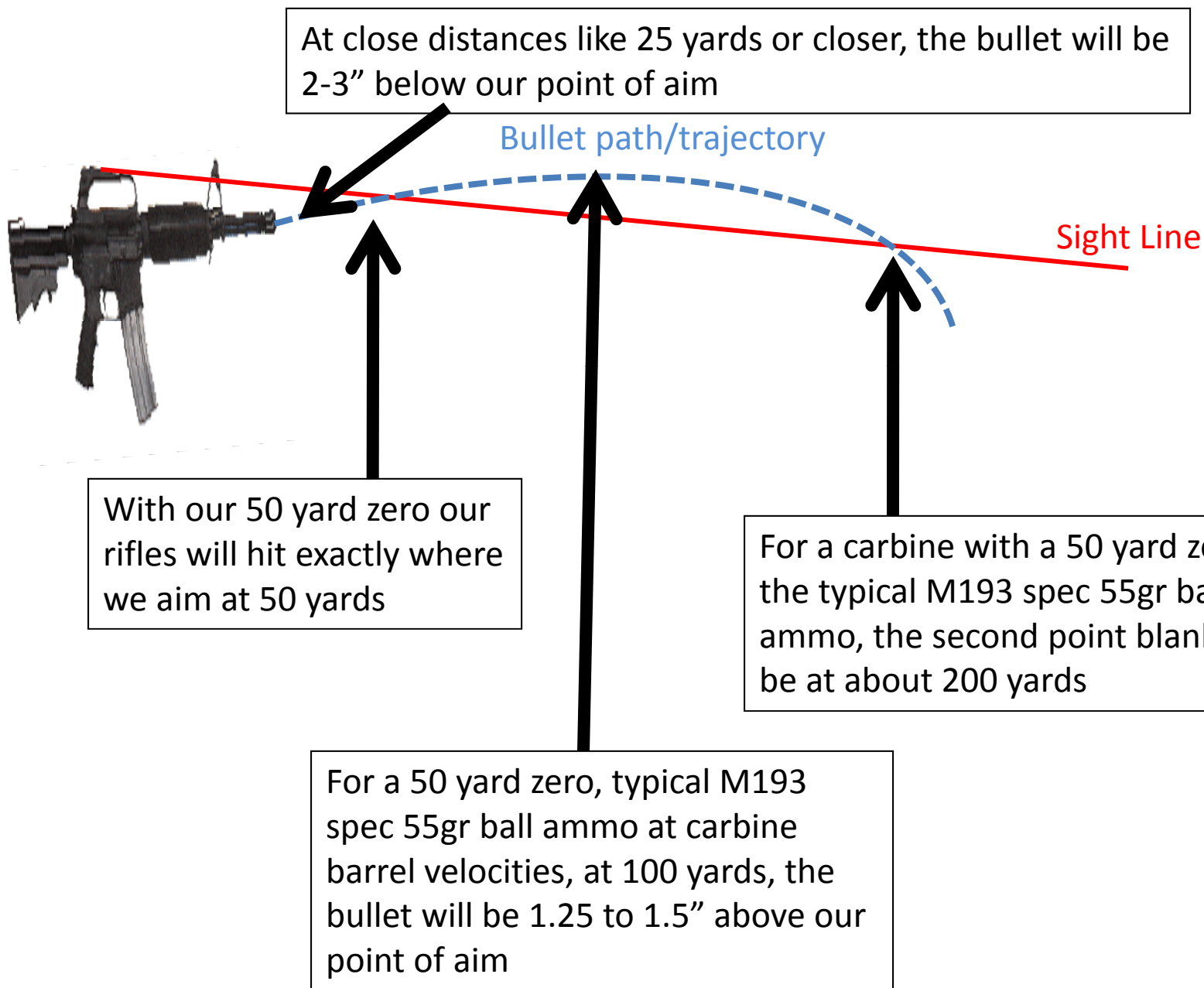


Today's zero'ing exercise, we will set our zero so that the sights are zero'ed for perfect point of aim (POA) equal to point of impact (POI) at exactly 50 yards for the initial point blank.....it is one of many zero'ing options that will work for your carbine/rifle, in the end which one is most appropriate is up to you, it is your choice...but for purposes of the class we will all use a 50 yard zero....



With our 50 yard zero our rifles will hit exactly where we aim at 50 yards

Based on the ballistics table or the ballistics calculator, and knowing our height above bore, our actual bullet muzzle velocity, and the ballistic coefficient of our bullet, we can calculate the second point blank and the trajectory of the bullet everywhere in between....



To understand the zero and ballistics for our specific rifle/ammo combination we need to generate the correct ballistics table that tells us where the bullet is relative to our sight line at various distances...

Handloads.com has a free ballistics calculator on the web that can be used to generate these tables...it is currently at:

<http://www.handloads.com/calc/>

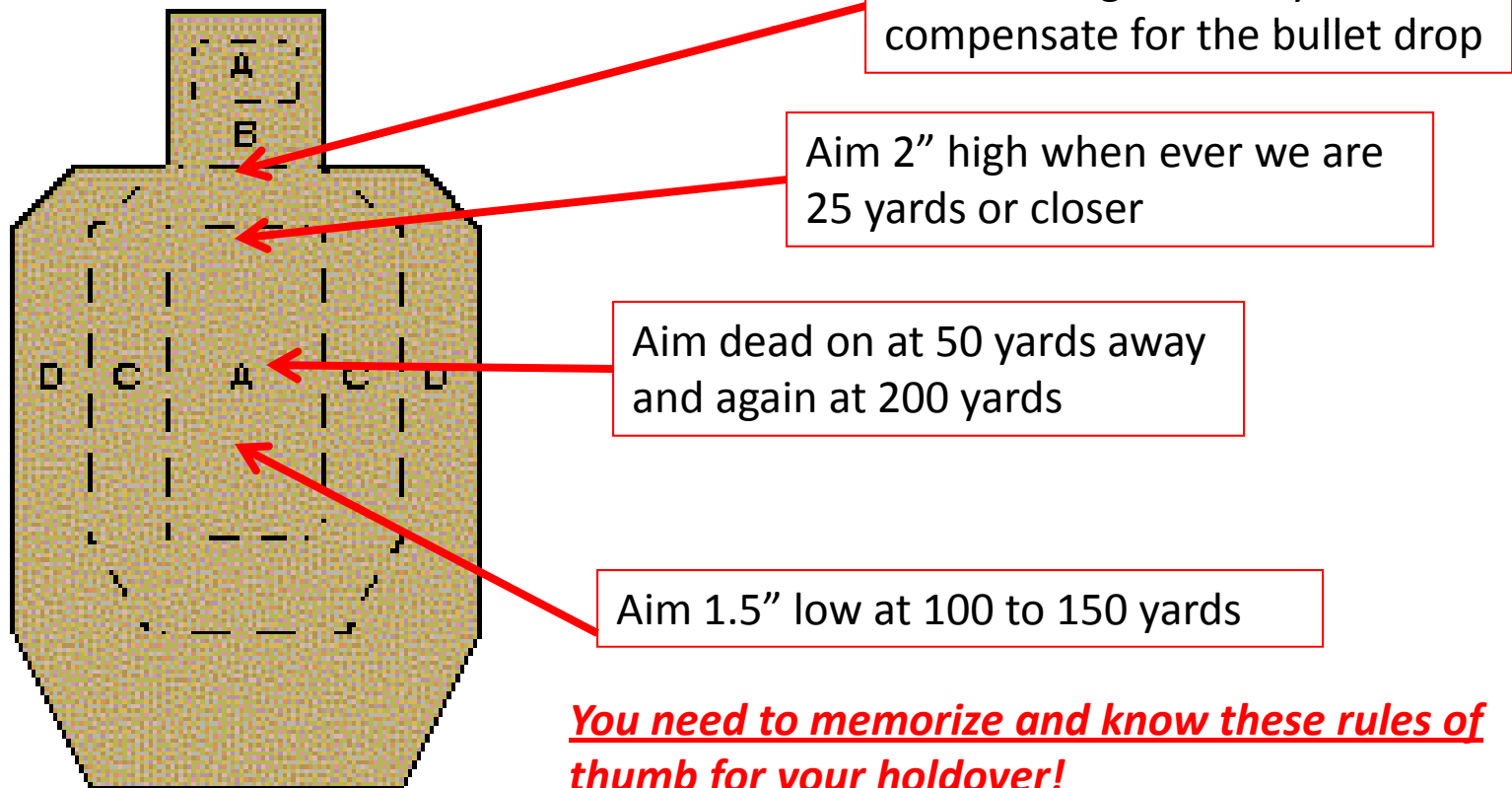
it will help you calculate ballistic coefficient for your bullet (small calculator on the left) and you enter data about temperature, zero distance, muzzle velocity, bullet weight, altitude, etc.....

With our ballistic chart, we can chop out the part of the data that helps us determine the trajectory at various distances, then put it on a card and take it with us. This example table is for typical M193 spec 5.56 bullets fired out of a 16" M4 carbine barrel on at 80 degree day in Central Alabama

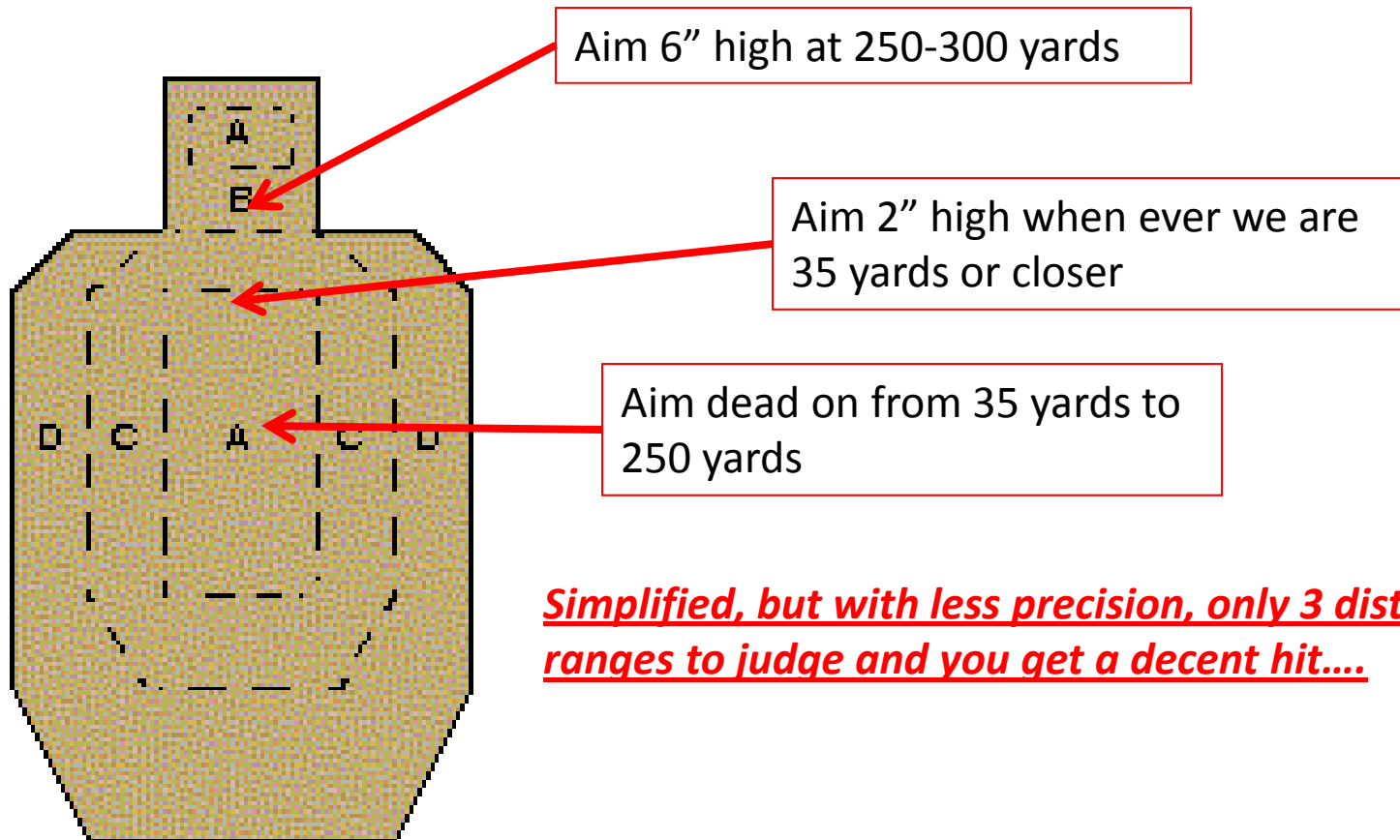
Range to Target in Yards	Point of Impact in (Inches)
0	-2.5
25	-1.12
50	0
75	0.83
100	1.36
125	1.56
150	1.41
175	0.9
200	-0.01
225	-1.34
250	-3.13
275	-5.41
300	-8.2

So what does all that mean in terms of aiming at our target??? We have to use “holdovers” or aim at a different point on the target from where we want the bullet to land in order to achieve the result we want....

It depends on the ammo, our barrel length, the bullet type....example, for M193 spec ball ammo out of a 16" carbine, using a 50 yard zero we can use the following simple rule of thumb to get good hits on a USPSA type target:



So what if you want a simplified hold over rule of thumb for this scenario?
One that assures we will get good hits but with less to remember and slightly less precision?



Simplified, but with less precision, only 3 distance ranges to judge and you get a decent hit....

So why might my range results vary from the calculated values, why might they change over time? Some common reasons:

- Ammo velocity will vary based on the ambient temperature
- Ammo velocity can vary from lot to lot for any manufacturer
- Stated velocity by the manufacturer is often for different barrel lengths, and individual barrels exhibit different velocities even if they are the same length, barrels erode and velocity drops over time
- Light conditions will impact your zero, time of day, bright or cloudy, can change your POI especially with iron sights
- Changes in your cheek weld position impact your eye's relationship to the sights, especially on iron sights this can impact your zero if your eye is not exactly in the same place with relationship to the sights when you first zero'ed
- Any sight system can be knocked out of zero or experience drift for mechanical reasons, meaning your zero moved, which is why you need to verify it often and confirm it when every you make changes to your sights
- The calculated ballistic coefficient of your bullet is approximate, your actual bullets may vary slightly based on who make them and which lot, bullet weight can also vary slightly with some manufacturers of what is nominally the same type bullet.

Bottom line, there are lots of things that can impact your zero and holdovers, you are the one responsible for understanding these principles and verifying the zero and holdovers for your rifle with that ammo you are using, and you need to commit your basic holdovers to memory in case you loose your ballistics card....

So how do I figure all of this out for different rifles and ammo combinations?

- First, make an informed zero distance choice for your intended purposes, no matter what you choose for your zero, you are the one who has to know the holdovers and be able to use them...
- Do that by using the free on line ballistic calculator and the best information you have about your ammo in your rifle to create a calculated holdover chart for your zero and this combination of ammo and barrel...
- Go to the range and zero based on your initial decision, then verify what your actual holdovers are at various distances...when verifying you can use the calculated holdovers as your initial point of aim at various distances to insure you are on the paper at least...
- Correct your hold over chart to change the theoretical to your actual results
- Now you have to commit it to memory....establish your rules of thumb for appropriate distances....

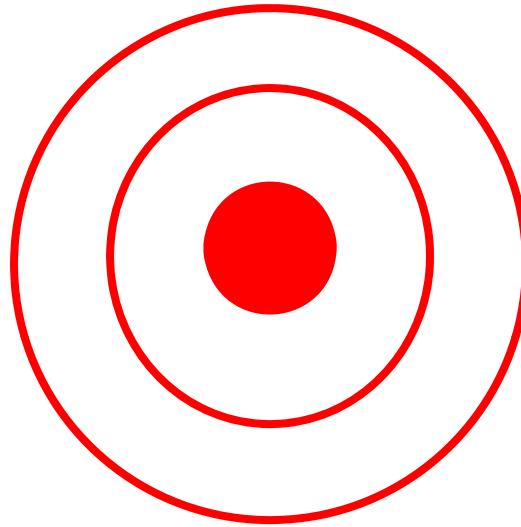
So mechanically how do we tweak our zero?

Every type of sight system or scope will have adjustments for windage, which is the left & right horizontal axis, and adjustments for elevation which is the vertical axis we just talked about.

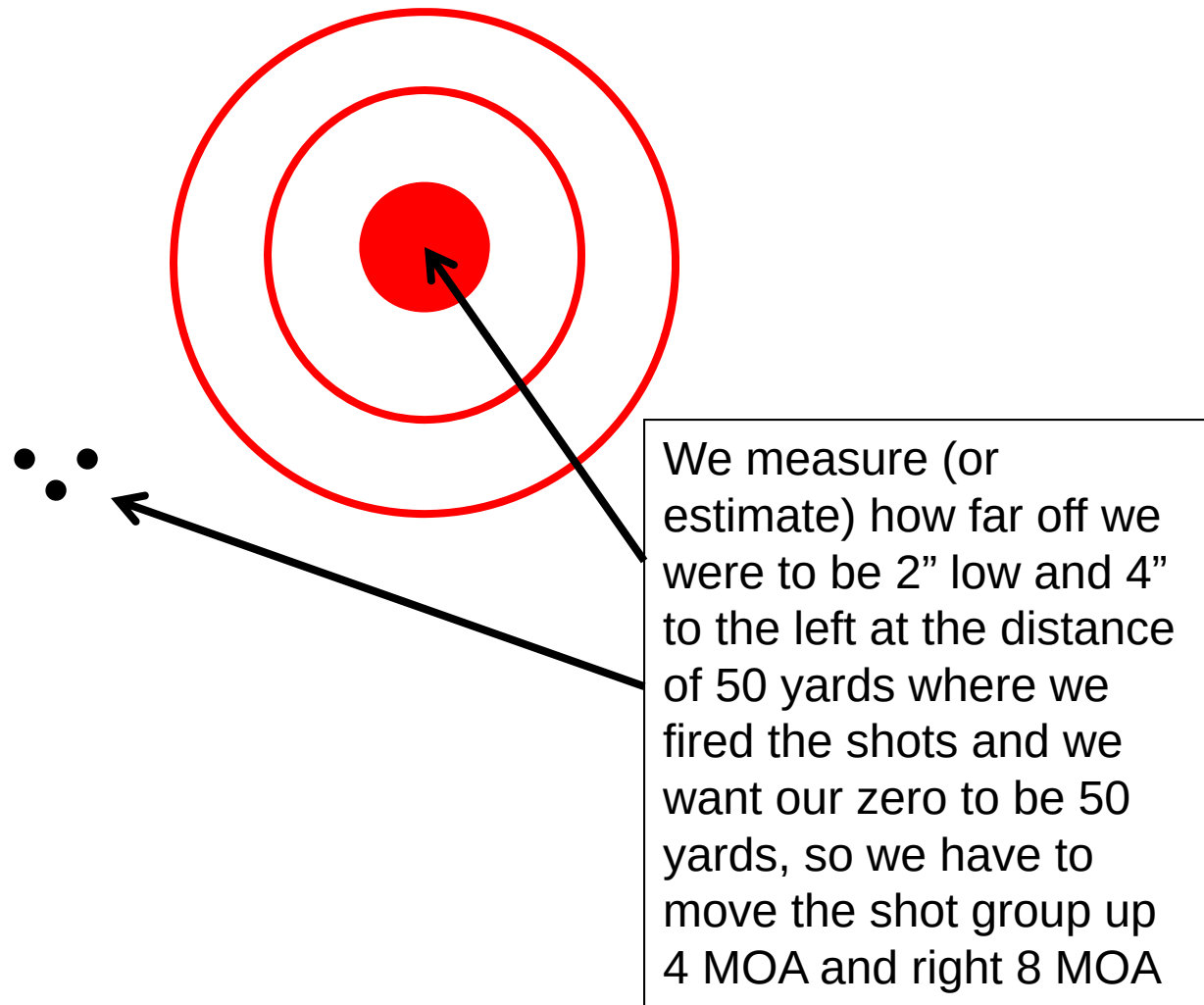
These adjustments are usually incrementally measured in number associated with minute of angle or MOA, for example the click adjustment on an sight or scope might be $\frac{1}{2}$ or $\frac{1}{4}$ MOA for each click, others may be a full 1 MOA per metered movement or even finer, like $\frac{1}{8}$ MOA per click.

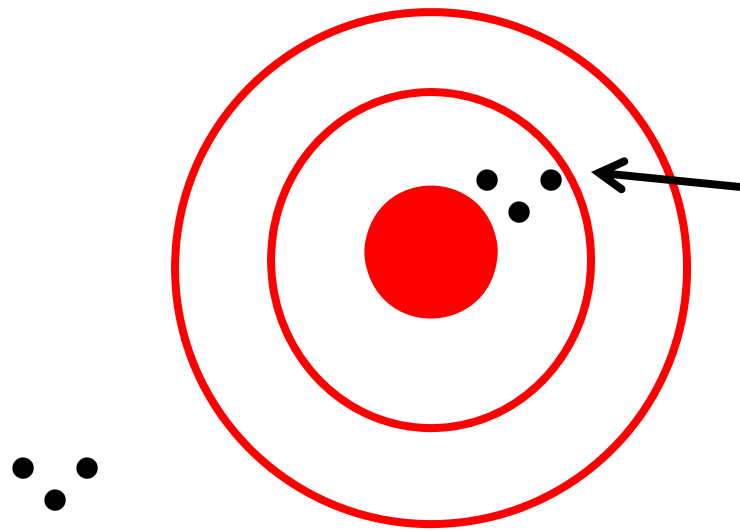
The important rule of thumb to remember is that 1 MOA = moving your point of impact (POI) by 1" when your target is at 100 yards, it is proportional to distance as well. This translates to 1 MOA = moving your point of impact by $\frac{1}{2}$ inch at 50 yards, $\frac{1}{4}$ " at 25 yards, or by 2" at 200 yards, 3" at 300 yards, etc.

To adjust our zero, we take careful aim and fire 2-3 shots at the same place, we then calculate how far off the center of that group of 2-3 shots is from the place we intended it to be, then we adjust the sights for the right windage (left to right) and elevation (up or down) the correct number of MOA adjustment clicks to make the shots move to the location on the target we wanted them to hit. Then we fire again to verify that our point of impact matches the point of aim we wanted it to. This process may have to be repeated several times to properly tweak our zero.

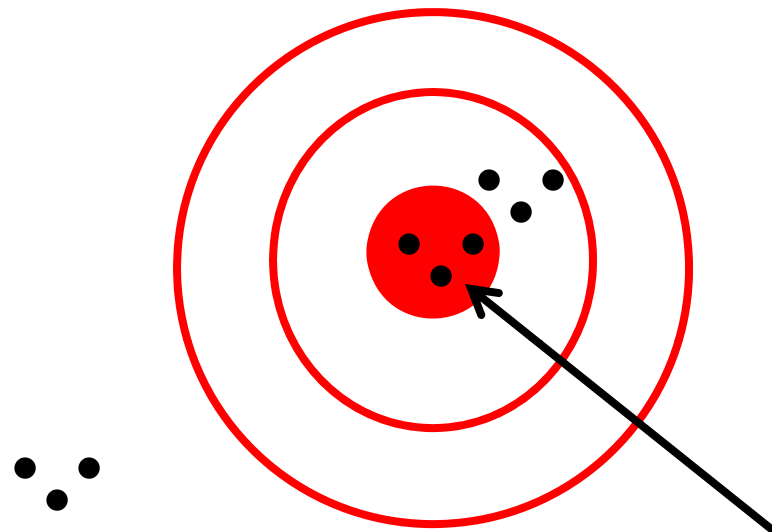


Our first three shots on target hit low and left from our point of aim





After our adjustment the second three shots on target hit high and just a bit to the right of where we aimed, so we need to back off the adjustment, our estimate is that the center of this second group is $\frac{1}{2}$ " high and $\frac{1}{2}$ " too far to the right, so we move the sight or scope adjustment 1 moa left and 1 moa down and prepare to fire another group



Our third three shot group appears to be centered about where we want it to be, on our point of aim, so we have achieved our goal of setting the rifle for a 50 yard zero....mission accomplished...almost, we will fire one more group to insure that the center of our shots is indeed staying where we intend for it to be on this target at 50 yards....

But what if I cannot get my rifle to shoot a consistent group and stay zero'ed?

There could be several causes....

- The scope or sights are loose and moving, loose scope mounts are often a culprit, also if the scope is able to twist or turn in it's mount
- If a scope, the internals could be broken and it won't hold a zero no matter what..must be repaired
- It could be that you have poor ammo or ammo that is mismatched for your rifle and not capable of consistent performance
- It could be you...are you flinching, keeping the same eye relationship with the sights/scope, keeping the same cheek weld, in a stable position, controlling the trigger?
- Could your barrel be worn out? As barrels degrade, accuracy and consistency disappear....
- Are the light conditions changing? Sometimes things as simple as the setting sun or passing clouds can cause zero errors....
- Are you certain you are using the exact same ammo from the exact same batches? Sometimes there can be variability between lots of the same ammo from the same manufacturer...

Scopes

- Non magnified red dot scopes (the expensive parallax free versions) are the most popular on AR-15's, specifically Aimpoint and Eotech (or Bushnell)
- The next most popular are magnified red dot scopes, Trijicon ACOG or Accupoint.
- Beware that cheap red dot scopes have too much "parallax" to be useful past 50 yards in most cases....they are not suited for rifle use...
- Some new 1x4 variable power scopes with illuminated reticules are becoming more popular, particularly in competition, but most are not durable enough for military use.