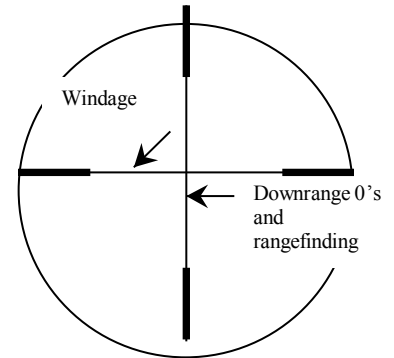


TACTICAL BALLISTIC AND RANGING RETICLE ANALYSIS

(Applying reticles for downrange zeroing, rangefinding, and windage reference)

--Understand and become familiar with terminology, i.e.:

- 1) Stadia = reference mark along x-hair (either dot or line)
- 2) Subtension = measurement of stadia "gaps" at known distance usually 100 yds.
- 3) milliradian (mil) = angular measurement of the std. military ranging reticle (dot to dot = 1 mil), 1 mil= 3.4 MOA, or 3.6 IPHY
- 4) MOA (minute of angle) = angular measurement of 1.047" PER HUNDRED YDS. (not just 100 yds.)—the most important, and frequently used concept for tactical apps.
- 5) IPHY = inch per hundred yards, another common angular measurement.
- 6) LPPT + UPPT = abbreviations for lower and upper plex post tips.
- 7) MPBR = maximum point blank range
- 8) Stadia Unit (SU) = stadia-stadia gap = 1 SU



--Learn to manipulate ballistics programs for practical field applications, i.e. calculation of MOA (or IPHY) drop table, and calculating windage reference. Normally ballistics calculations are accurate enough to allow for long-range 1st shot connections, WHEN accurate data is supplied by the user.

A) DOWNRANGE BALLISTIC RETICLE ZEROING, INCLUDING SIMPLE PLEX

Note-- Important to remember that in most scopes the reticle is in 2nd focal plane, so that as magnification changes, so do reticle stadia subtension measurements. Once zeroing, ranging, and windage reference are established the calculations are only good at 1 magnification. This is OK, since applying reticles for long-range shooting, is done only when time allows for calculated shot placement, USUALLY AT THE HIGHEST POWER.

1) Trajectory vs. Target Size

The simplest of tactical trajectory compensating systems where range, target size, and trajectory are known. Shooter simply holds over the required amount by using target height as a reference. Fair viability for game to intermediate ranges. The next step beyond simple "Kentucky" elevation.

2) Referencing Holdover with Simple Plex

Note-- Has a degree of viability, and can be quickly applied, but lacks the range of ballistic reticles.

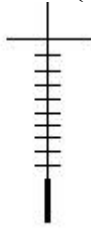
Determine the 100 yd. subtension of x-hair to plex post tip (IPHY or MOA calculation), by measuring with yardstick @ 100 yds. (accurate measurements here are critical—as close to .1 inch as possible), or checking tech. notes on manufacturer's website (often a good idea to verify the factory supplied values as well, as they are sometimes inaccurate).

Run a ballistics program, and determine LPPT zero range, by calculating drop in MOA (if

ballistics program doesn't calculate MOA already—most do) using the following formula—**(drop in inches/range) x 100 = drop in IPHY. If ballistics program calculates drop in MOA then you must convert IPHY to MOA by dividing by 1.05**

Example for a .22 cal. 55 gr. Blitzking (BC= .271) @ 3470 fps mv, 200 yd. zero: hypothetical scope's PPT subtension = 4 IPHY, 400 yd. Drop = 16", so (16/400) x 100= 4 IPHY. LPPT zero then= 400 yds.

2) Stadia Unit (SU) System



Interpolating addtl. range zeros (for our example, <400 yds. in 25 or 50 yd. increments)- These can be calculated, and referenced (by interpolating) along the vertical x-hair in tenths of the total “gap” (x-hair-LPPT) IPHY measurement once PPT subtension is known (this system is commonly used by military snipers and practical field shooters that employ the mil-dot reticle for holdover by mentally dividing the dot to dot stadia units into tenths for referencing drop (inserted diagram above is a simple depiction of the interpolated system for the plex reticle). This system can be applied more accurately than just guessing approximate holdover between stadia if the trajectory curve doesn't allow the reticle to correspond to even 100 yd. intervals at normal intermediate ranges. Though not quite as accurate, it can be applied faster than turret comeups. As in our above hypothetical example, we may want to determine what the approximate holdover would be for 200- 400 yds. in 25 or 50 yd. increments instead of guessing, so if x-hair is zeroed @ 200 yds. and the LPPT is 400 yds. then we simply refer back to our trajectory curve to find the drop in inches for each 50 yd. (or 25, if so desired) interval. Here are the ballistic program calculated drops:

250 = -2.1”

300 = -5.4”

350 = -10”

Now we must convert each drop again to IPHY by applying the same formula as above or-- IPHY drop @:

250 = (2.1"/250) x 100 = .8 IPHY

300 = (5.4/300) x 100 = 1.8

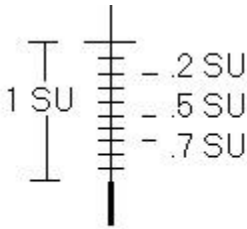
350 = (10/350) x 100 = 2.9

Now simply divide each yardage IPHY by the total PPT IPHY (4) to obtain vertical reference in tenths of the total stadia unit:

250 = .8 IPHY/4 IPHY = .2 of the total stadia (plex) unit (SU)

300 = .5 SU

350 = .7 SU



What we have now calculated is an interpolative system along the vertical x-hair that allows for a more precise reference for the “in-between” ranges (in this example between x-hair and LPPT zeros).

3) Ballistic Reticle Zeroing



With the plex reticle, it can easily be seen that if the user wishes he may also use the UPPT as a main zero (instead of the x-hair), in effect becoming sort of a short 2 stadia ballistic reticle-- BUT THIS SYSTEM WILL ONLY WORK IN THE FIELD WITH A FIXED POWER SCOPE (OR A SCOPE WITH THE RETICLE IN THE 1ST FOCAL PLANE), because if the magnification changes, so then does the stadia (PPT) subtension, or simply put, the UPPT zero will no longer be known. This is very rarely employed, but those that do, report a surprising success rate with it. Actually, what we are about to do is present the calculations that will work for any ballistic reticle (it must be noted here that ballistic reticle manufacturers provide simple systems to zero their particular reticles, but the method outlined below will work with any reticle, and is often more thorough, and accurate than the generic systems supplied by the companies). As in our above example (if we used a fixed power plex reticle scope with the same “gap” measurement) the UPPT then becomes our 200 yd. zero, and the x-hair would be 4 IPHY below that (400 yds.), and then the upper SU (x-hair-UPPT) would be divided interpolatively the same as above. Now the LPPT becomes 8 IPHY below UPPT, or referencing the ballistics program (or IPHY calc.), will provide a 3rd zero of 550 yards. Again, simple calculations as above will provide the interpolation zeros along the lower SU (x-hair-LPPT) of the x-hair between 400 and 550 yds.:

$$450 = 5.25 \text{ IPHY (from ballistics program)}$$

$$500 = 6.5$$

Now it must be remembered here that for interpolation purposes each ballistic reticle stadia gap is a unit unto itself, and we will reference the interpolation relative to the closer stadia’s zero (x-hair, in our present example). This means that we must subtract the closer stadia’s IPHY measurement from each additional 50 yd. IPHY drop to get the IPHY

difference between the stadia zero and the interpolative 50 yd. zeros:

$$450 \text{ yd.} = (5.25 \text{ IPHY}) - 400 \text{ yd.} (4 \text{ IPHY}) = 1.25 \text{ IPHY}$$

$$500 \text{ yd.} = 6.5 \text{ IPHY} - 4 \text{ IPHY} = 2.5 \text{ IPHY}$$

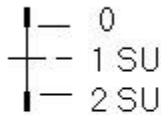
Now again simply divide the 450, and 500 yd. IPHY by the total gap IPHY (4) to reference those particular zeros in tenths of THAT PARTICULAR stadia-stadia gap (x-hair- LPPT in our current example):

450 yd. zero = $1.25/4 = .3$ of a stadia unit below x-hair or referring to the x-hair as our 1st stadia unit (1.0), 450 yds. then becomes 1.3.

500 = $2.5/4 = .6$, or again as above 1.6.

Now after verifying calc's at the range, simply make a range card or sticker with the calculated info. for quick reference, as follows:

Yds.	SU (stadia unit)
200	0
250	.2
300	.5
350	.7
400	1
450	1.3
500	1.6
550	2



It must also be noted here that with ballistic reticles each consecutive “gap” measurement in IPHY will be a little larger since the stadia measurements are designed for a “generic” long-range trajectory curve which is parabolic in nature-- not evenly spaced like the mil-dot, or as in our current example, the plex reticle.

If the shooter wishes to engage targets beyond the limit of the ballistic reticle to longer ranges, he should then recalculate the computer trajectory model with the ballistics program (in MOA or IPHY comeup calc.'s) by replacing the original zero by the lowest stadia's zero in the ballistics program to calculate the needed comeups to as far out as the shooter wishes, using the lowest stadia as the aiming point.

4) Subtension changes with magnification changes

Another system that is occasionally used for zeroing the plex reticle to long-range is to adjust the magnification such that the LPPT coincides with POI at even yardages downrange. This system is identical to the Leupold Range Estimating System available in the VX III, or Vari-X III line, but instead of adjusting the reticle subtension to bracket a certain animal or target size downrange it is simply used to adjust the LPPT to correspond to a certain POI downrange. It is also based on the same principal as the Leupold Varmint Hunter reticle's dual zeroing system for cartridge groups of similar trajectories. Their new

Tactical Milling Reticle (TMR) as well as some models of the Burris Ballistic Mil-dot is also based on this same system as well. The principal behind all this is that, **as magnification changes, reticle subtensions also change linearly**, such that a simple ratio and proportion formula is all that is needed once reticle subtension and desired range are known. But the calculation is actually **inversely proportional, since as magnification INCREASES reticle subtension DECREASES**. It is also important to note here that the power ring must be calibrated properly for magnification. If it isn't, then the system won't work, and the only alternative is to shoot groups at each range, and adjust the power ring until the LPPT aligns with the group.

So then, using the same above example let's say we wanted to calculate the magnification change necessary to obtain a LPPT zero for addtl. range in 50 yd. increments to 600 yds. from the LPPT 4 IPHY 400 yd. zero. @ 12X. Now we already know the IPHY bullet drop at all the ranges from the ballistics program, so now it's just a simple matter of plugging the unknown figures into the formula to get the magnification changes for each range. The formula is as follows: **highest magnification/ desired IPHY (or MOA) = unknown mag./stadia IPHY (or MOA) @ highest power**. Although it may appear complicated, the formula is actually quite easy to apply. It's simply a matter of plugging in the figures for the following IPHY values calculated earlier from the ball. program:

$$450 = 5.25 \text{ IPHY}$$

$$500 = 6.5$$

$$550 = 8$$

$$600 = 9.75$$

$$450 \text{ yd. magnification zero then} = 12X/5.25 \text{ IPHY} = xX/4 \text{ IPHY} = 9X$$

$$500 = 12/6.5 = X/4 = 7.4X$$

$$550 = 6X$$

$$600 = 5X$$

Now a range sticker can be made up and again attached to the scope or gun for reference. Some may even go so far as to mark the power ring for range zeros. The system has some viability, but goes against the grain of common thought that as range increases magnification should also increase—in this case it becomes the exact opposite. I have seen this applied in the field quite effectively.

B) RETICLE WINDAGE REFERENCE

1) Stadia Unit (SU) System



The “stadia unit” system for windage reference is based again on a reticle subtension vs. downrange measurement as all the systems are, and is calculated the same as the SU holdover. Again using the above example (now MOA instead of IPHY) of a 3.8 MOA PPT subtension (remember divide IPHY by 1.05 to get MOA subtension) with our 55 gr.

Blitzking @ 3470 fps. We see from the ball. printout that the MOA measurements for a 10 mph x-wind from 200- 600 yds. are as follows:

200- 1.5
300- 2.5
400- 3.5
500- 4.5
600- 5.75

Now simply divide by our 3.8 MOA left +/-or right PPT subtension, and we get windage holdoffs in tenths of the SU (stadia unit) or:

200- .4
300- .6
400- .9
500- 1.2
600- 1.5

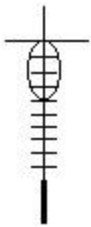
This info. can again be written on our range sticker along with the holdovers. Finer measurements can also be calculated (50 yds.) although not really needed since the holdoff is so close that it sort of becomes redundant, and the less info on the sticker, the better, to avoid confusion. Windage holdoff is often based on a “best guess” system as well, oftentimes making it, practically speaking, semi-quantitative at best.

2) Windage Reference Relative to Target Size

Has some merit once practiced, but little if any advantage over the SU system. The system is self explanatory, and is simply based on target measurement vs. windage calcs. exactly as holdover system #1 above. A disadvantage of the system is target angle or presentation. If target presentation is from a different angle than broadside, the system quickly gets much more difficult.

C) RETICLE RANGEFINDING

1) Stadia Unit (SU) Rangefinding System



Important to establish as a backup to the rangefinder. Again, simply based on a reticle subtension vs. downrange target size. Ranging systems are needlessly complicated, and can be very simply accomplished with any reticle size by adapting the mil-ranging formula. Here is the adapted formula for ranging using a MOA or IPHY stadia-stadia measurement for determining range in yards:

Target size (in inches) X 100/stadia subtension = Target-stadia factor
Target-stadia factor/ # stadia units (SU) target brackets in tenths of a unit= range in yards. Again, appears complicated, but extremely easy to apply.

Reticle Ranging Example:

Suppose we're after coyotes (12" avg.--back-brisket), and plex reticle x-hair- LPPT subtension is 4 IPHY as before, now simply fill in the blanks to produce a reticle ranging scale as follows:

12" X 100/4/1 SU = 300 yds. (coyote brackets the 4 IPHY gap at 1 SU perfectly).

12" X 100/4/.9 SU = 335 yds.

12" X 100/4/.8 SU = 375 yds.

12 X 100/4/.7 = 430

.6 = 500

.5 = 600

.4 = 750

.3 = 1000

.2 = 1500

Referring to the SU plex diagram above, if you can imagine the oblong circle as a coyote's chest, back-brisket (admittedly a far stretch) we can see he brackets @ .4 SU or 750 yds. As range increases it obviously becomes geometrically harder to determine. Range can be assessed as far as the shooter feels comfortable with his measurements/calculations (for me it ends @ 400-500 yds., although I have successfully reticle ranged targets as far as 725 yds., and have heard reports of 900+ yd. reticle ranging). Efficiency of reticle ranging varies with size of target vs. magnification vs. size of reticle subtension. It should also be noted here that the plex reticle offers a fair amount of ranging flexibility. When ranging larger targets such as deer and elk, the UPPT-LPPT gap @ 8 IPHY (in our case here) would be better used for reference, especially since the interpolative system can be applied easier with the x-hair representing the .5 mark.

2) Ballistic Reticle Rangefinding

Now if a ballistic reticle with more than 1 stadia is used for a larger target (deer/antelope/elk) then the shooter can select 1 stadia as the main ranging SU, and use the others to more accurately approximate tenths of that unit as follows:

Cow elk = 20" back-brisket (b-b)

Using the 3-12X Burris Ballistic Plex reticle we have the following IPHY values for each stadia:

1 = 1.4

2 = 4.1

3 = 6.8

4 (LPPT) = 10.1

Now comes the question of which to select for rangefinding purposes. The best stadia to select is the largest one that will go as close to the max. point blank range (MPBR) when the animal brackets perfectly at 1 SU.

The 3rd stadia @ 6.8 IPHY calculates to approx. 300 yds. @ 1 SU for our hypothetical cow elk (6.8 x 3 = 20.4), and the 4th stadia @ 10.4 calculates to about 200 yds. Since most big game rigs will easily get to 300 yds.+, for MPBR we should select the 3rd stadia for our

main SU rangefinder. This means that we can make a range scale as above, as follows:

$$1\text{SU} = 300$$

$$.9 = 325$$

$$.8 = 370$$

$$.7 = 420$$

$$.6 = 490$$

$$.5 = 590$$

Now we can see that, at least for my uses, .6 SU is about the limit of accurate rangefinding for this particular combination, and it can also be seen that there is an additional 2 stadia between the x-hair and the main rangefinding stadia (#3). Why not put them to work for us by dividing the 1st and 2nd stadia 1.4 IPHY and 4.1 IPHY respectively by the entire rangefinding gap @ 6.8 IPHY to determine where these 2 stadia lie along our rangefinding scale above as follows:

$$1^{\text{st}} \text{ stadia} = 1.4/6.8 = .2 \text{ SU}$$

$$2^{\text{nd}} \text{ stadia} = 4.1/6.8 = .6 \text{ SU}$$

Now it can easily be seen that the 1st stadia provides little in the form of a reference for ranging, since .2SU is useless for accurate reference (1470 yds.). But the 2nd stadia is perfect for not only determining the .6 SU measurement, but also the limit of our max. distance for a comfortable shot @ 490 yds. Putting additional stadia to use for reference eliminates some interpolative guesswork—and since it's there, it may as well be put to work.

2) **MPBR (Max. Point Blank Range) Reticle Rangefinding**

Most hunters keep their variable power scopes set at a lower magnification while hunting, but instead of adjusting it randomly, why not calculate a lower power that can be used as a quick rangefinding aid that will allow the hunter to quickly determine whether the animal is within the MPBR or not? Typically a quick long shot takes a few seconds to guess range and it's corresponding holdover anyway, so we may as well calculate a system that provides for the least amount of guesswork possible, assuming it can be applied just as quickly. As an example let's assume we're hunting cow elk as before with our big game rig (whatever it may be), scoped as before with the 3-12X Burris LER Ball. Plex reticle. Let's also assume that we've referred to our hypothetical ballistics printout, and we've calculated a CONSERVATIVE MPBR of 325 yds. where the bullet drops about 3/4ths of the total distance below our broadside elks vital zone of around 15" or so with a center mass hold. Now this means that we have to figure out a magnification that will allow us to bracket the elk perfectly between 2 particular stadia when she's standing broadside @ exactly 325 yds. Now since we already know the IPHY measurements for each stadia it's a simple matter of figuring what those measurements will be in total inches @ 325 yds. by simply multiplying each IPHY value by 3.25 (for 325 yds.), as follows:

$$4.1 \times 3.25 = 13.3''$$

$$6.8 \times 3.25 = 22.1''$$

Now if we remember from before, as we decrease magnification, reticle subtension increases, and it's easy to see that the 6.8 IPHY stadia isn't going to work since it's

already too large @ 22.1" at 325 yds. at 12 power, and if we decrease power it's just going to increase the subtension. But our 4.1 IPHY stadia's 13.3" 325 yd. gap might just work since we have some "room" to increase reticle subtension to 20" as we decrease power. So by applying the inversely proportional equation that we used before to calculate downrange zero changes with magnification changes (the exact same principal), we can very simply calculate the magnification the power ring must be set at to bracket the elk at our MPBR. But instead of using each magnification's IPHY measurements as before, we will simply use the total # of inches @ 325 yds. (13.3-20). The equation then becomes: **highest magnification/ desired inches = unknown mag./# inches @ highest power @ MPBR**. All we need do now is substitute the known values to calculate the magnification we need as follows: $12X/20" = xX/13.3"$, $x = 8$ power. Now if we set the magnification to 8X, and we're presented with a quick long shot at our quarry, if necessary, we can quickly bracket the elk between x-hair and 2nd stadia, and if she's as big or bigger than the bracketing gap, simply aim dead center and shoot. Of course, once again this is assuming that the power ring is calibrated properly. Obviously, the system can be used with any ballistic or ranging reticle once stadia subtensions are known, but works particularly well with many plex reticles for simplicity's sake. Obviously the shooter could just put up a 20" target @ 325 yds., and adjust the magnification until the target is bracketed between the selected stadia (possibly the only option if the power ring isn't properly calibrated), but understanding the principals involved behind manipulating reticle subtensions goes a long ways towards efficiently applying tactical systems in the field.

Once we have established our "tactical" system, it's a simple matter of putting all the info. on a range sticker or card, and attaching it to the gun or scope somewhere for quick reference. I even keep a 2nd range sticker on my laser, and 3rd stored for future reference. This becomes very handy when 2 guys are working together as a team. The spotter can then relay the required info. to the shooter, such that the shooter can focus all his attention on the shot itself. A system like those I've outlined above keeps the tactical marksman from having to perform calculations in the field when shots are encountered at intermediate ranges (MPBR- 5 or 600 yds.). Beyond this, meteorological and environmental conditions may require changes to the sighting system.

D) REFERENCES

- 1) Burris Ballistic Reticle Tech. Notes—
<http://www.burrisoptics.com/technotes.html>
- 2) 50 Cal. Sniper—Hard Target Interdiction by Dean Michaelis
- 3) Leupold Ballistic Aiming System, and new TMR/SPR reticles--
http://www.leupold.com/products/Info_Ballistic_Aiming_System.htm
http://www.leupold.com/products/tactical_products/reticles_tactical.htm
- 4) Animal Silhouette Measurements/TDS Tri-Factor Reticle—
http://www.kahlesoptik.com/products/animal_silhouette.html
http://www.kahlesoptik.com/products/tds_reticle.html

- 5) Perry-Systems Exbal Ballistics Calculator—
www.perry-systems.com
- 6) Mil-Dot System—search internet, and—
<http://www.shooterready.com/>
- 7) Precision Shooting 1, by Ward Brien—
<http://www.snipertools.com/book.htm>
- 8) Free Downloadable Ballistics Programs—
<http://www.eskimo.com/~jbm/calculations/calculations.html>
<http://www.the-king-family.com/Shooting/BallisticsCalculator01Aug2004.xls>
<http://www.jacksonrifles.com/ballistics.htm>
<http://www.beartoothbullets.com/resources/calculators/balistics/DATA.htm>
<http://biggameinfo.com/BalCalc.aspx>
<http://biggameinfo.com/BalCalcAdv.aspx>
<http://ballistics.ntinnovations.com/Default.aspx>