Unravelling The Mystery of Shooting in the Wind

Ross Mason

Introduction

This booklet is mainly intended for the novice 50 m shooter. It could be those who have decided to take the plunge from indoor shooting and are about to meet the wind enemy. Or maybe those who have been beat around the head by the windy conditions all too prevalent in our fair country and are looking for reasons to keep shooting! Hopefully the wind will be seen to be more friendly after reading this.

It started out as a quest to discover what is happening “in the wind”. I am an inquisitive person by nature and my work career has always been associated with measurement and improving it. So I had to have physical and logical reasons to be able to understand and analyse what is happening.

It has been a long quest and learning has never stopped.

I am indebted to my fellow shooters who have discovered their skills from sheer hard work and bitter experience. It was sometimes difficult to extract logical reasons for some of their actions. A lot had difficulty adequately describing what they were looking at.

This is an endeavour to explain what they might have been trying to tell me.

When I started 50m shooting, I asked a fellow club member what he does about the flags. He said " I watch them like a hawk!". That was all. It took me at least another 15 years to figure out what he ***might*** have meant by that piece of advice! Finding decipherable information on wind shooting - anything and anywhere - has been damn near impossible!

Sources of information have included: magazine articles from the likes of ”Target Gun”, internet mail lists, CDs (“Winning in the wind” by Lones Wigger and Lanny Basham), books by Bill Pulham and Frank Henekrat, discussion and experiment. I even tested draft versions on Olympic shooters.

But I would like to think that if I had access to this information earlier in my shooting career then I am certain I would have found it more than useful.

I have tried to arrange the chapters in a sequence of discovery. From the motion of bullets in the wind and their point of impact, the flags, your first shots, your first steps to learning techniques for handling the wind, mirage. And finally a few equipment and preparation suggestions.

I hope you find it informative, instructive and useful.

Please, don’t be afraid to tell me:

1) Yes they are
2) You can improve them by…..

Most of all, have some fun!

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The Misery of Wind

There has to be a reason for how and why the wind takes hold of - especially your - bullets and sends them to all points of the clock punching 7's, 8's and 9's into an otherwise perfect piece of cardboard!!

Why does a bullet get deflected the way it does?

It is always useful to try and find a rational explanation for physical effects so that when a new fact emerges you can test it against that explanation and modify it to fit the new fact. Then you don't need to invoke imaginary reasons for things that happen. That is a simple explanation of the scientific method.

There are a couple of ideas. I will explain away one commonly held view and present another one that appears to explain the facts with a little more clarity.

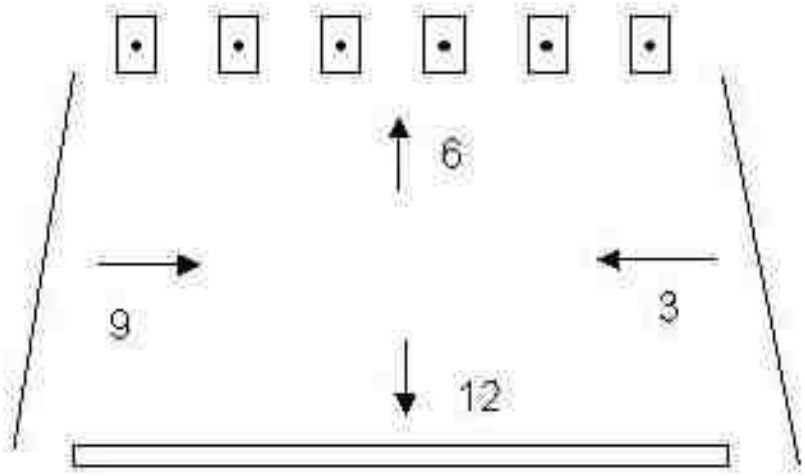


Diagram 1 Showing Wind Directions

The Wind Spin Theory

A commonly heard explanation for a bullet 'climbing' and moving to the left with a 3 o'clock wind, is that the spin of the bullet 'rolls the air' under it and therefore it climbs up over the wind. Likewise with a 9 o'clock wind it is 'sucked down' by the spin. This 'apparently' gives the reason for the 10 - 4 line for these two winds. When the wind is from 3 o'clock it is blown up and to the left and when it is from 9 it is to the right and down.

We can demonstrate this spinning effect with a ping pong ball. It is based on the Magnus Effect. Grab your ping-pong bat and ball and hit some top spinners and undercutters. Note how top spin forces the ball down more than when it is just hit straight. As in Fig 1. Likewise when it is undercut it tends to rise and seems to float as it moves along. Whether the ball is moving or the wind is blowing across the ball makes no difference to the forces on the ball.

Again, note that when the ball has topspin the force is down. That is, it tends to be forced down by the spin. While the wind spin idea says is that it should rise. And likewise when it is undercut it rises. What the wind spin idea suggests is that it should fall. This idea does not fit the facts.

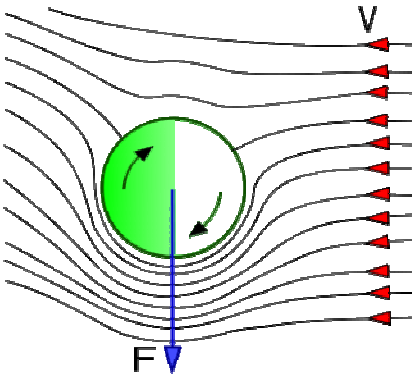


Fig 1

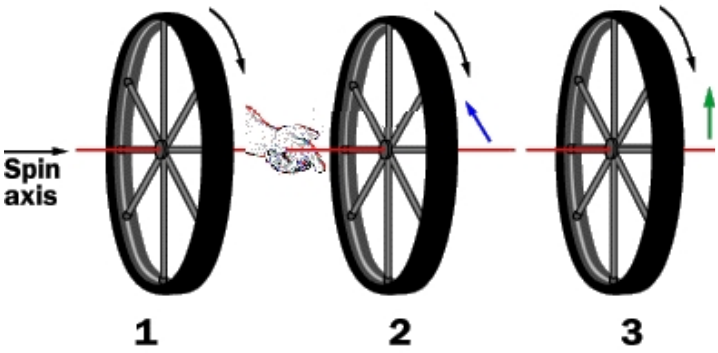


Fig 2

The other Idea.

For demonstrating this idea I use a bike wheel with a 25mm dowel 'bullet' attached to the axle on one side with rifling drawn on it. I also have an extension on the axle nearest me so that I could hold the wheel. A standard bike wheel will work just as well. See Fig 2.

Hold a bicycle wheel with the axle pointing towards you as in 2 in Fig 2. Spin the wheel clockwise as you see it. This is fairly close to what a bullet is doing as it travels towards the target. Now if we get a good spin up we can demonstrate the precessional forces on a spinning body. These are the forces that let a gyroscope stay up on one leg! Let us now give the front of the bullet (the wheel axle on the other side of the wheel) a nudge from the right in the direction of the blue arrow and check what happens. The axle is forced to the left and some 'other' force moves the tip of the bullet UP in the direction of the green arrow. Let us now give it a nudge from the left. The axle is forced to the right and points DOWN. This is precession. It is a force which acts at right angles to an applied unsettling force. Play with a wheel and investigate which way it moves depending on the wheel rotation. Try nudging it from underneath as well.

If we now relate this to a bullet we can show that when the nudge is the wind and from the right, the bullet nose is lifted slightly. It presents itself to the air in an attitude that will tend to generate lift. Likewise with the wind from the left, the bullet nose is dropped and is thus deflected downwards. This idea fits the facts so it might be useful!

Head winds and tail winds do not seem to affect a bullet to the same degree compared to the 9 and 3 o'clock winds, other than the effect of a straight rise and drop due to the bullet having differing deceleration forces on it with the head and tail wind.

I have yet to find an instance where the gyro effect cannot explain a queer wind. A hoary one for example was at Ardmore. Where a wind from about 1 or 2 o'clock (head wind from the right) seems to throw the bullet up to 11 o'clock. This is more pronounced the further to the middle mounds you are. There is a hollow in the middle of the range. Some thought and playing with the bicycle wheel will reveal that if the wind is coming up as well as towards you, there is now a vertical component to the wind. I believe we now have a case of 3 dimensional shooting. This lifts the bullet a little, due to the right to left precessional effect of the wind, and drifts it a little to the left.

Bullet Point of Impact (POI)

Diagram 2 shows a generalised view of the effect of a constant wind from differing directions on the POI. Note the 10 - 4 line (its more like 9:30 - 3:30 but 10-4 is easier to write) for 3 and 9 o'clock winds, and the rise and drop for 6 and 12 o'clock winds. The "openness" of the oval ***may*** be more squashed than is shown. I have yet to convince myself how "open" it is. However, I ***am*** convinced the oval exists!

I developed this diagram with a physicist friend who was into MathCAD. We made some assumptions:

- The wind blew the bullet left and right equally;
- The wind lifted and dropped the bullet with tail and head winds equally;
- There was some lift and drop associated with 3 and 9 o'clock winds.
- That head and tail winds give no sideways movement.

Inputting just those 4 variables/guesses of what influences a bullet's flight produced Diagram 2. It is an ellipse of major axis along the 9-30 to 3-30 line and minor axis along the 12:30 and 6:30 o'clock line.

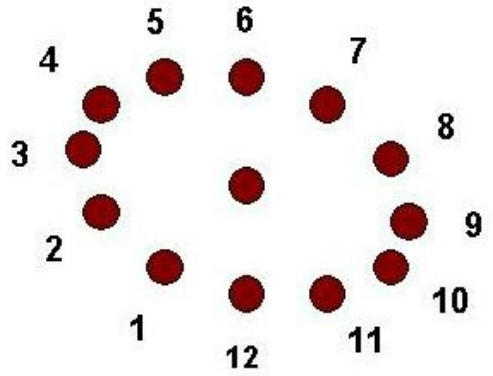


Diagram 2
Bullet POI in wind from indicated direction

We altered the shape of the ellipse by changing the amount of each variable. The ellipse changed its aspect ratio, slope and "openness" but it still remained an ellipse! I picked this one for clarity.

A couple of interesting observations show up in Diagram 2.

1. The effect of wind from the 3/6 quarter has less scatter than wind from the 6/9 quarter. The 3/6 scatter takes up about 80 degrees and the 6/9 takes up about 100 degrees.

2. Winds from 5 and 11 give the greatest elevation changes. Intuitively one may think that 6 and 12 would.

Observation 1 gives us a simple opportunity to improve our group size. If you have the choice of a wind switching from 1/2 to 10/11 (head wind switching from L to R) then maybe you should pick the 10/11 wind. It will give you a little leeway in picking the direction because it will produce a smaller group.

Note also that the maximum displacement from the centre is with the wind directly from 3 or 9 o'clock - given the same velocity for all directions. So if the wind shifts from, say, 2 to 4, the group will be hook shaped to the right. Almost like a small boomerang. Ditto for 8 to 10 o'clock. This means if you have set your sights for a 3 o'clock wind, then any shot that is further out to the left - when you have convinced yourself that the wind is no stronger than what you have picked - then that shot is due to you. Likewise those shots to the right appear to be influenced by a left wind. But it is only the slight change in direction of the wind causing the group shift.

Getting this picture well sunk into the brain will enable you to analyse your groups a lot better.

Remember this is for a perfect group. The effect of larger group size is to enlarge the size of the dots. That is, more scatter around each of the points around the clock.

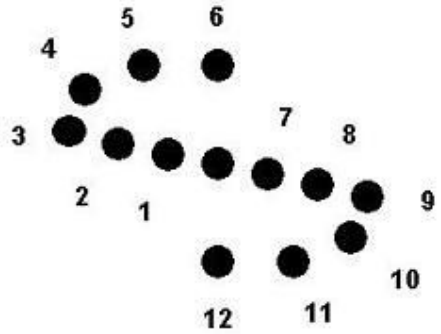
The 10/4 elevation changes about 1 click for every 3 or 4 clicks of windage. Up for a R to L wind, down for a L to R wind.

Comments on other wind diagrams

Prior to figuring out my ellipse, the only diagram I was aware of was Brookwoods "Target Gun" version. After talking about this and my ideas in Michael Ray's ISSF page a few years ago - before the site was closed down - I was contacted by Don Williams and he kindly sent me a version he uses. I also I bought Lanny Bassham and Lones Wiggers version in their CD "**Winning in the wind**".(www.mentalmanagement.com). Their "ellipse" is very closed and they make reference to the amount of vertical deflection being a little more for rimfire than for bigbore. But it is obvious they do not share as open an ellipse as mine. As I said, there may be the possibility of the real effect being somewhere between the two.

But later in another part of the CD, Bassham and Wiggers mention the need to compensate for head and tail winds. So they too suggest something else is happening.

From "Winning in the wind"



From Target Gun by Brookwood

Brookwood's "Target Gun" Smallbore series was the trigger that got me thinking about this whole business. His wind diagram showed abrupt changes in POI for head and tail winds between 6 and 7 and 12 and 1.

The physics suggested to me that this needed reviewing. I needed convincing that such small changes in wind direction can cause such large changes in the POI.

I have tied to keep an open mind and have tested my diagram many times and have yet to find a need to modify it. I just need to improve all the other aspects of shooting to get the benefit of the tool!

To the novice shooter....it can appear like witchcraft, but hopefully you may now have some clues as to what is happening out on the range!

Learning Wind Tactics

For the beginner it is wise to proceed into reading the wind one step at a time. When you first try 50m shooting it is very difficult to figure out what is happening. One of the hardest concepts to grasp is the change in group size from indoor to 50m. It gets big. And frankly, on the 50m range the days of multiple single hole groups are rare.

So the first lesson here is to not alter the sights too often. A group measuring 3 or 4 shot diameters on some windy days looks quite small!! It is imperative you learn to develop an understanding of "The Group" rather than fiddle with the sights on a shot by shot basis. We will talk about that later.

When you get to the range the first thing that strikes you is how much the flags move about, they change direction and they change flap angle. It appears to be chaotic. But there are a few things that begin to stand out. There are times when the flags all point in the same direction. That is good. There are times when adjacent flags point in different directions. That's not so good. There are times when the flags just sit in the same direction and angle for minutes on end. That is really really good!

So the first skill is simple: ***Learn to observe***.

Reading Wind Flags

Watching these fiendish bits of cloth nonchalantly flapping in the breeze in an attempt to gather useful clues as to what the next bullet is going to do exercises the mind greatly.

Here are a few things to look for that can give vital clues and good references.

Flag Stages

All flags exhibit different flapping stages in wind.

1. The vertical no movement stage
2. The barely perceptible lift of the end of the flag
3. The steady angle from near vertical to about 10 to 20 degrees
4. The lazy wriggle
5. The lazy flap
6. The unsteady irregular waving
7. Horizontal

Putting a value to the expected bullet deflection at these stages can be fraught with difficulty. Flags may be dry, wet, heavy, short, fat, thin and even how they are hung affects it. All these factors may give differing clues to the expected deviation. Believe me, it can take a fair breeze to lift wet flags so be wary in the rain!

But the stages are common to all flags (as far as I have found).

For instance, the vertical (1) up to the steady angle (3) can be relatively easily read in terms of angle. You can use marker points in the background to estimate the angle by measuring the height the bottom of the flag lifts.

The interesting bits to note are the transitions from one stage to the next. The step from 3 to 4 is a sudden transition. It occurs over an extremely narrow velocity range and is very useful for picking a constant wind strength to shoot on.

Likewise the transition from 4 to 5 can be seen to occur quite suddenly. But the movement within a stage can look the same over quite large velocities. So the angle of the flapping is all that can be discerned really.

There is a perception that groups seem to tighten up when there is a fraction of breeze (off centre of course!) and probably with the wind around the 2 to 3 transition. Why this may occur is unknown but there may be a preferential steadying effect on the bullet with a wind coming from one direction. A bullet takes time to “sit down” and fly straight. It wobbles just after it leaves the barrel for some metres and this time may be shortened with a slight breeze. Note: This is a rational guess on my part.

Shooting on a Lifting wind V a Dying wind

Here is one gold nugget I picked up. Intuitively, it may be expected that a flag appears to move the same in both a lifting wind (increasing velocity) and a dying wind (wind velocity dropping). It is a dangerous assumption.

The instruction I heard was to "always shoot on a rising wind".

In other words, the instruction suggested that the transition from say, stage 3 to 4 in a lifting wind was not the same wind velocity when the flag changes from stage 4 to 3.

It appears that the rising wind transitions occur at higher velocities and the reverse transition occurs at a lower velocity. Likewise trying to pick the flap of the flag moving within a stage in both rising and dropping velocities is dangerous. Once it is flapping the only clue available is the angle the flag is flapping at.

Why this is so, took a paper in the Scientific Journal ,"**Nature**", to explain.

The illustration below the picture is a graph from the paper showing the hysteresis effect of the flag transitioning from smooth to flapping and then from flapping to smooth.

The vertical scale is a measure of the amplitude of the flap and the horizontal scale is the "velocity".

Because the authors were using soap films and a piece of cotton fibre as a “flag”, they were unable to change the flow velocity, they changed the length of the 'flag' instead. This, in effect, is the same as changing the velocity of the flow.

Sure enough, the transition up is a higher velocity than the transition down. Also note how the amplitude changes little between these transition velocities. Thus the reason for the comment above about only the angle giving a clue between flag stages.

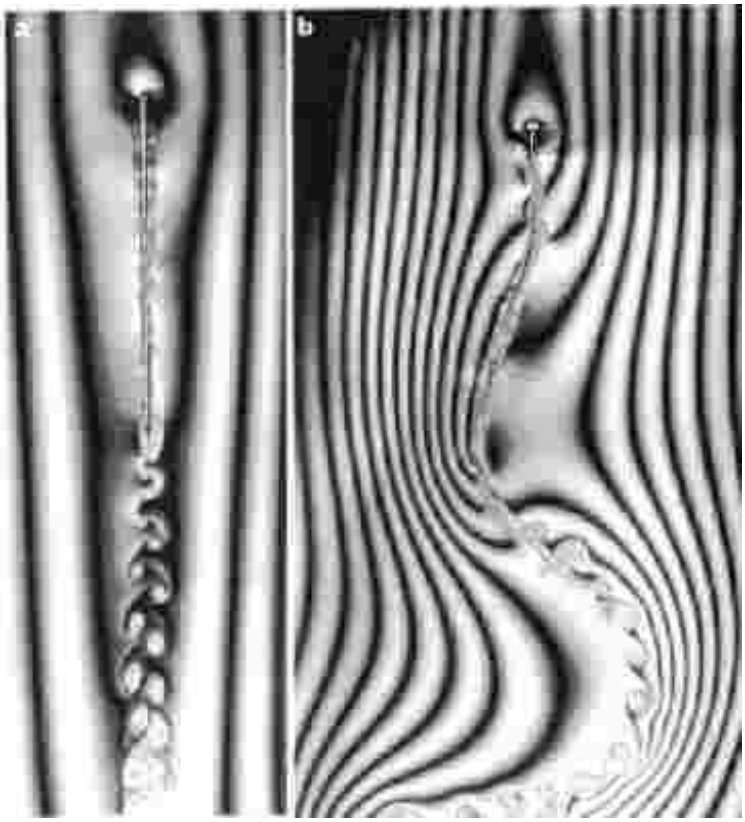
Following the arrows shows how the flag jumps to an unstable state then stays unstable until the flow slows and then jumps to the stable lower state.

Rather than throwing one or the other piece of information away, we can use both depending on the conditions.

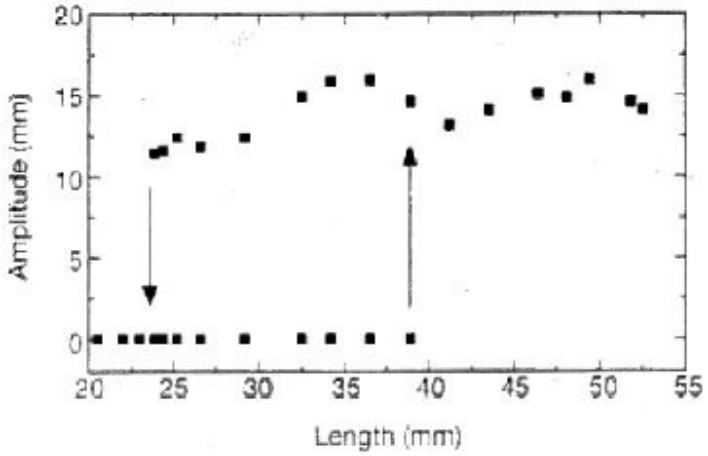
We all know that there are occasions where the wind rises in velocity quicker than it drops. In this case it is perfectly legitimate to use the dropping transition as the wind marker. If the wind rises slower than the drop then use the rising transition.

Or, it would be perfectly okay to set your sights on the rising transition and use the lower transition to aim off on.

Flexible filaments in a flowing soap film as a model for one-dimensional flags in a two-dimensional wind
Jun Zhang, Stephen Childress, Albert Libchaber, Michael Shelley
Nature **408**, 835 - 839 (14 Dec 2000) Letters to Nature



The photos depicts the flow around the flag. (a) steady, (b) in the flapping stage.



Is the flag pointing away or towards me?

It can be a problem to read if the wind is a 10 o'clock wind or a 8 o'clock wind. Is the flag pointing towards you or away from you?

Two shooters, Don Brook from Australia and Ian Newton of Wellington, gave me useful clues.

Don's clue: If there is no wind netting on the range and you are able to see a reasonable set of flags along the range and if the wind is from 10 o'clock, the flags to your left will tend to point more towards you as you go down the flag line. If the wind is from 8 o'clock the flags on your right will tend to point away from you as you go down the flag line .

Ian's clue: If the sun is out you can see the shadowed underneath part of the flag if it is pointing away from you.

Your first shots at 50m

The Group

Remember the comment earlier about the groups being bigger than indoor. The averagely good 50 m group around at the moment measures edge to edge about 12 to 13 mm. The bull is 10.4 mm across. Adding the two 5.6 mm diameters of the bullet, the edge to edge group that will hit the bull is about 22 mm across. So this ammo group is close to half what it takes to hit the bull. There is some room in there for your aiming and wind error!!

Now just think about the fact that the ammo group is 12 to 13 mm. If you fire two shots and they just missed overlapping then it HAS to be accepted they could be in the same group. This means that shots within a good group can still appear to be 2 or 3 clicks apart. That is quite a long way!!! So you must not be tempted to alter on every shot. Wait until 3 or even 4 shots are fired before deciding where the group looks like it is building. Alter the sights after that and then think about the next 3 or 4 shots. It is a good idea to work in groups of at least 3 shots when considering altering the sights.

Consider this scenario. You fire 2 shots that are split. You decide the second one is too far away and alter towards the first by 3 clicks which should plonk it right on top of the first. The next shot is fired and it hits 3 clicks the other side of the first shot. That MUST tell you if the sights were left where they were it would have keyholed the first shot. And the group may have been only 1 click away from where it was building not 3.

Remember to always figure out the centre of the group first and only then alter the sights to centre the group into the middle of the bull!

The first box: The best thing a first time 50m shooter can do is take a box of ammunition and shoot five shot diagrams until the box is empty. Get someone to lie beside you to get the rifle zeroed in near the middle of the bull on the first target. You can use a blinder and you can watch with your scope. Don’t worry where the shots are going. Just shoot and observe. Do not adjust the sights any more once your assistant has zeroed them for you. Just make sure you fire good shots that are aimed and released the best you can. And use a blinder.

That first box will get the first thrills out of the way.

Get the targets back and have a look at them. Do not score the shots but do look for patterns. Do you notice any emerging? For example are there groups in the bull, or left and right of the bull? High or low? Odd flyers well away from the groups?

The second box. This time shoot with no blinder. You will have to squint but that's OK for now. Shoot about four groups of five shots but this time observe a 10m flag near you that can be seen with your non aiming eye and pick a flag direction to shoot all 20 shots with. Breath, aim and then leave the eye open so that you can see the flag. When it is pointing in the direction you want, squint as needed and fire the shot.
The groups should be developing such that they will be in one general area on the target and away from other groups that were probably fired when the flags were pointing in other directions during the first box.

If you have succeeded in this you have passed the first major hurdle.

The rest of the box can be used to pick the same direction and a strength of wind. This is estimated by the angle of the flag or by using one of the flag transitions mentioned earlier.

Repeat this type of practice over a few more weeks before trying to shoot for a score. Take your time, rest often and breath normally while waiting for the right condition to fire. When it comes to shoot for a score, try shooting only 20 or 30 counting shots for the first few times. It will cut down the frustration and your endurance will build over that time as well.

Once you are proficient enough at watching one flag, try observing what is happening with the flag at the 30m line closest to your lane. Does it show the same direction every time the 10m flag shows your chosen condition? The same strength? Ask yourself "What would happen if I checked the 30m flag each time the 10m flag was right?" Do it and see if it improves the group.

So we come to the tactics that will need to be learnt after you have mastered the art of two flag watching. Learn and practice them well before using them in a competition.

Waiting for the flags to show the same conditions is number one. Adjust the sights for that condition and develop confidence that there will be at least 60 times this will occur during the match. This is the technique emphasised above in the two flag condition. This is the technique that would be used by a wind coach in a team shoot. They will watch the flags until "your" condition sets in and tell you to shoot. This is the number one skill that you must master. Succeed at this and you have acquired the skill of reading the wind well. Make sure you try and achieve this using different wind conditions, rather than just your favourite condition on your home range. You are now able to figure out direction and wind strength. The next steps will be easier!

Note also that it is important to develop shooting skills that allow you to shoot quickly if your conditions are present in short periods. Be ready to react, aim and fire, then reload, aim and fire as soon as possible while ensuring it is not hurried! And develop confidence that you can take a break and rest if the wind picks up. Practice these skills regularly even when conditions are good.

Aiming off

Aiming off is extremely useful when time is an issue and conditions vary. There are two variations to this. Aiming off with the rifle on a calm wind zero and sights set on a wind and then aiming off.

A good tactic to develop in wind shooting is the ability to 'aim off' or 'shade'. This is the act of deliberately shifting the foresight picture so that it is offset in the opposite direction to the wind deflection. This technique enables you to shoot quickly instead of waiting for the 'best' wind. Remember there is only 75 minutes for 60 shots prone – and even less time per shot for the 40 shots in 3P!!

Of the two variations the zeroed sights is the easiest to master.

Sights / Rifle Zeroed

The dot in the middle of Diagram 3 is your zeroed rifle fall of shot. Perfect no deflection conditions. Trentham's Allen Range every Sunday afternoon. Diagram 3 shows the sight picture with the foresight enclosing the bull. The wind deflection is as shown by the other dots around the foresight, again for a constant wind from differing directions. (The dots are now greatly exaggerated relative to the foresight.)

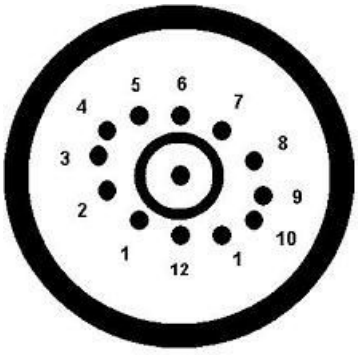


Diagram 3
Sight Picture for zero, no wind

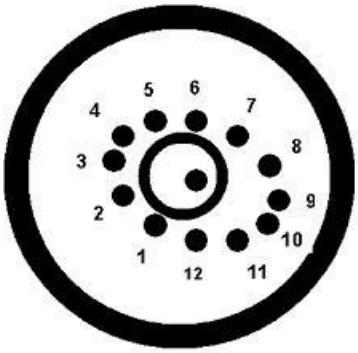


Diagram 4
Sight Picture for 9 o'clock wind

We have to aim off in the OPPOSITE direction to the wind deflection.

To show the foresight picture required to compensate for the bullet deflection of a 9 o'clock wind (fall of shot at point marked 9), see Diagram 4.

It is the OPPOSITE to the deflection and the rifle is now aimed upwind.

Likewise we can do this with other wind directions. Always remembering to offset the sight in the opposite direction to the deflection, that is, upwind.

Compensating for just horizontal windage may not be enough in some cases. It can be useful to compensate for the elevation loss as well. Practice indoors to learn to pick how much to aim off. Wind the sights and try and hit bulls by compensating. You do get quite good at it!!!

This is the second technique to practice once the skill of two flag watching and shooting on one condition is achieved.

Sights Adjusted

Now, when you have selected a wind and adjusted the sights to bring the shot into the bull for that wind, the other instance occurs.

This is fairly complicated to figure out let alone compute it on the fly while you are shooting, but bear with me. Remember again, to always think about compensating in the OPPOSITE direction to the deflection.

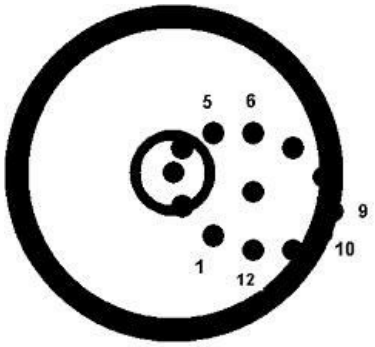


Diagram 5
Sights adjusted for 3 o'clock wind

Lets pick an easy one again. Imagine you have sighted in on a 3 o'clock wind. So what we have done in effect is move point 3 on Diagram 2 until it is centred in the foresight. I have exaggerated again for clarity sake. You are now shooting with a normal sight picture, Diagram 5, but the sights have been offset to compensate for a 3 o'clock wind. In other words, diagram 2 has been shuffled "upwind" so that the POI is now in the centre of the bull.

OK, you are aiming with a centred target. The wind changes slightly from 3 to 4 o'clock. Which way do you aim off. Remember OPPOSITE.

Careful thought will show that you have to aim off towards 7 o'clock for a slight change of wind from 3 to 4 o'clock. Now say it moves around to 2 o'clock. We now have to aim off towards 11 o'clock. A tad further you may notice due to the slightly differing amounts of deflection.

Now read it all again - reading carefully - at least 20 times. It just doesn't seem logical which way you have to aim off - especially when you have zeroed on a wind and you are trying to compensate for slight direction variations.

Note also, that for all other winds other than 3 o'clock, the bullet will hit to the right of the bull. When this happens I bet you will wonder where the left wind came from! You can work your way around the ellipse and figure out where you would need to aim off. For instance, if the wind started coming from 6 o'clock then you would need to aim off at about 8 o'clock. Look where the 6 is on the ellipse and offset to the opposite side. In other words, put the bull at about 2 o'clock in the foresight.

It is handy to make transparencies of the back sight, foresight and diagram 2 and move them around for differing wind conditions.

Reversing Wind

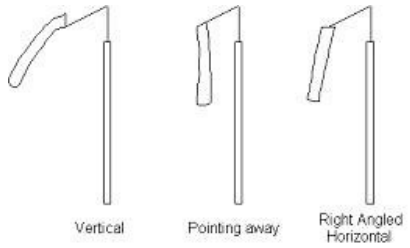
From Diagram 5 it can see what will happen if you have adjusted your sights for a 3 o'clock wind and the wind flicks to 9 o'clock. The bullet will go twice as far in the opposite direction to the adjustment. Because you have adjusted the sights and that setting, for an opposite wind, shifts the POI further away from the centre! Make sure you at least shoot with the flags always pointing in the same direction! It shows the "twice the error" consequence of not watching for the wind reversing.

There is a copy of Diagram 2 on the last page so you can take it to the range the next time and consult it. You may find it of value at the oddest of times.

Flag Mounting

This brings me to a pet idea of mine. The ISSF rules give no instruction as to how to mount the flag. There is a recipe for the type of material for the flag but no mounting instructions.

Lets assume the flags are mounted on a vertical pole and a wire leg is free to spin in a hole in the top of the pole. The flag can be mounted in any of three ways on the end of the wire leg. It can be with the narrow edge of the flag vertical , The narrow edge of the flag pointing away from the pole and the edge at right angles horizontal to the wire. The diagram below shows the three methods.



I promote the usefulness of the "Right Angled Horizontal" flag.

The beauty is that Ian's idea for figuring away or towards flags is extended with this mounting. It also doesn't rely on the sun to shadow the flag. The underside of the flag can a different colour to the top. Then the underneath side of the flag is easy to see. Mounting the flag this way means that whenever you can see the underside it means the flag is pointing away.

Neither of the other two methods enable this effect to be as easily exploited.

But. It would be wise to make sure you have sets of the other flags as well so that you can learn how they look while you are shooting. Other ranges in other countries may not be quite so friendly.

Which flags should be watched?

I have to admit that there is a fair amount of suspicion about how one should follow the “rules” when it comes to this. But here goes.

It is an accepted rule that the wind in the first third of the range affects the bullet the most. Believe it.

The upwind flag closest to you gives the most information at the time the shot is fired. That is a fairly general rule to keep to the fore.

For deflection sideways it is the 10m flags that will give the best indication of how far its going to move. The generally held view is that a given wind deflection close to the shooter ends up with a larger deflection at the target than the same wind hitting the bullet at 30m down the range. Simple geometry can show this.

At a first approximation, the 30m flags seem to hold the most information for the vertical deflection. If the 30m flag shows a head wind up around the 3 to 4 flag angle then take it into account and aim off a little high.

As far as sideways indicating flags at 30m are concerned, certainly take them into account if the 10m flag is going the same way. There will be an additional deflection.

Experience will teach that it is very range dependent. If the range is clear and little swirling goes on then both flags need to be taken into account and are usually quite readable. If there is wind-netting or trees causing swirl then it can be a lottery.
In swirling cases it can be advantageous to shoot your sighters on a mixture of flags. For instance, the 30m and the 10m in opposite directions or calm 30m and blowing 10m. You will be quite surprised at what some combinations can achieve. I have found instances where a zeroed rifle will plonk shots in the middle for some opposite combinations. That can be handy if you have a calm spot to shoot on as well as some wind.

Keep an eye on a flag a few mounds upwind from you. This can indicate what is going to happen in 5 to 10 seconds time. This can give you time to prepare for the shot and concentrate on the near flag.

I have not mentioned how many clicks to alter for differing winds. It is SO dependent on range, weather conditions or flags etc. Unfortunately it is up to you to see which wind(s) affect the POI when you shoot your sighters. Use them well to your advantage to learn the wind on the day.

Mirage

Generally mirage occurs on hot days. Usually when it gets above 20-22 C and is enhanced by the type of ground, time of day, dew, clouds and recent weather conditions – especially rain. And especially if the sun shines bright right afterwards!

Mirage is the shimmer that you observe looking at objects that have a larger amount of air between you and it. The 'ocean' on a hot straight road. The temperature of air is rarely constant and there are temperature gradients everywhere. When this occurs the air is in motion due to convection currents. These gradients also change the density of the air. If the density changes then the refractive index of the air changes. It is the chaotic changes in refractive index that cause the light waves to be bent or to be refracted and shimmer.

It is not the same effect as the wind. Wind shifts the ***bullet*** while it flies towards your target. Mirage moves the ***picture*** of the target that you are aiming at. It makes it appear somewhere it ain't!

If the ground between the shooter and the target heats up then pockets of warmed air lift off the ground and rise through your sight line. If it has rained or dew is present on the ground, the evaporating moisture enhances the refraction as well. On the range the air close to the ground usually will be warmer than the air above and the light rays tend to get refracted or bent. Now all this is visible through the spotting scope. Fig 4 shows what it looks like through the scope in differing mirage conditions. The red circle is where the target really is.

Fig 3 Open circle is the image of the target the shooter sees when the air is calm and the mirage is boiling

On a calm day when mirage is present, Fig 4, Picture 2 – Boiling, the air is bubbling up from the ground. If you could 'see' the light ray side on you would see light travelling from the

target to the shooter in an arc with a high point somewhere in the middle of the range. So you can imagine if you look down the sight line the image of the bull appears to be higher than the real position of the bull. Though to you it still appears to be in a straight line. Fig 3.

The other pictures in Fig 4 end up being variations of Fig 3. You can imagine that if the air between the shooter and the target starts moving then the light ray line gets shifted as well.

So the important point to note is ***that the image of the target shifts in the same direction as the mirage appears to be moving.***

The fuzzy edge of the targets in Figure 4 show which edge gets 'torn' by the mirage. That is, ***the edge gets torn in the direction of the air movement***.

Pictures 3 and 4 in Fig 4 show when the air is just beginning to move left or right. Through the scope you will see the torn edge being shifted to the left or right as the shimmer begins to move. Pictures 5 and 6 in Fig 4 show when the air is just about to, or has begun to move the flags. Of course there will be a continuum from boiling to horizontal movement depending how much air movement is present.

Once the mirage shows some semblance of horizontal movement it is said to be "running". It is a good idea to learn to estimate how much running it is doing. The speed of motion of the shimmer is an excellent way of estimating the effect of the mirage.

The mirage will always be the first indication of air movement. That is, well before the flags begin to move the mirage will indicate the direction and the beginning of the wind drift. It is fascinating to watch the mirage moving in one direction, become stationary and boil, then move off in the other direction and the flags remained absolutely motionless throughout.

It is therefore important to watch the mirage for wind direction especially if the flags are not indicating any wind.

To enhance the mirage, try defocusing the scope a fraction so that it is focused somewhere about the 40 m mark between the shooter and the target. You are then looking at a bit more of the air mass and the shimmer shows up the edge of the target better. However, you lose a bit of definition on the target and you will need to focus back onto it if you want to see where your shots go. When shooting single shots on a target it is easy to see if the shot is near the middle. That is all that is needed. But with 2 or 5 shots per diagram it means there has to be a compromise in how much you view the mirage or the target.

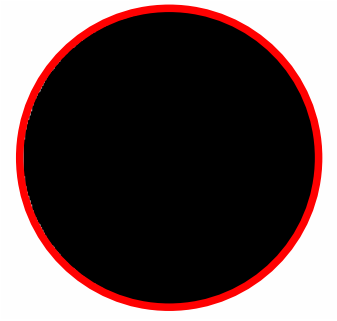
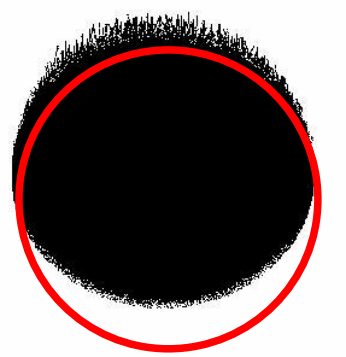
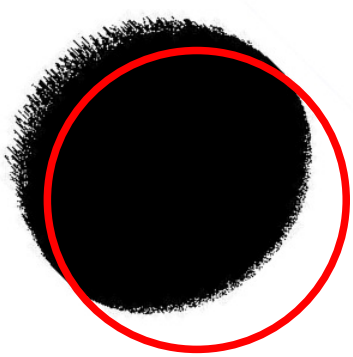
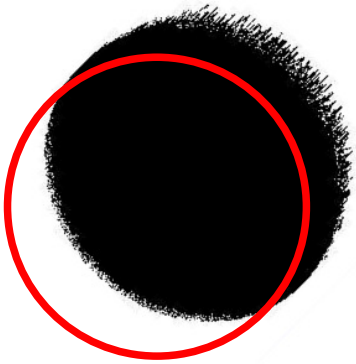
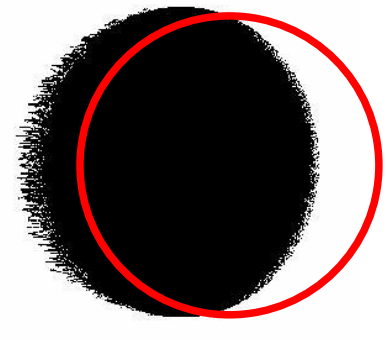
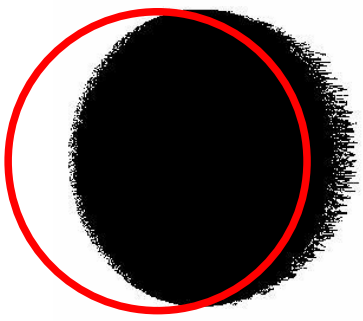
Sometimes the air is visible behind the target and you can see the drift better. But remember you are looking at the air behind the target not in front of it so use it as an indicator rather than gospel.

When there are clouds the mirage has a tendency to disappear when the clouds are blocking the sun and activated when the sun hits the deck again. So it is important to keep an eye on the lighting conditions and check repeatedly for mirage.

Boiling Mirage is extremely difficult to shoot on. The image will shimmer high and move from left to right when it is up there. What can occur is a shifting view of the mirage from picture 2 to 3 then 2 then 4 then 2 then 3 etc. You can imagine that the POI can be just about anywhere.

A first tip – Wait when it is boiling and watch for it to settle down in one direction long enough for you to fire a shot. Use the scope to see when this occurs.

Figure 4

	
1 No Mirage	2 Boiling Mirage shifting image high
	
3 Mirage with mix of boiling and some air movement shifting image high and left	4 Mirage with mix of boiling and some air movement shifting image high and right
	
5 Mirage shifting image left due to R to L wind movement	6 Mirage shifting image right due to L to R wind movement

Once the mirage begins to show movement in either direction it is then safer to fire the shot. How much to alter the sights is of course the point of sighters. But with experience you will be able to guess the alteration.

Generally, it is safe to put a couple of clicks right or left and a couple down if pictures 3 or 4 are present long enough for a shot.

As the mirage flattens out and begins to "run" more and more horizontally, as in pictures 5 and 6, the elevation adjustment comes off but the windage adjustment may need to be increased.

However, here is a warning. In the overlap between pictures 3 and 4 and 5 and 6, a nasty combination of effects happen.

You will recall the effect of wind alone on the bullet. That is, a R to L wind lifts the shot along the 10 - 4 o'clock line. When the mirage is looking like pictures 5 and 6 and some flag is showing some steady angle, there is a combination effect from both mirage and wind. That is, the mirage is lifting the image (thus the shot) and the wind is also trying to lift the shot.

This is the first nasty and the effect will be to raise the POI a fraction and shift it further out. This will be further than the effect of just wind and further than just mirage.

When the wind is from L to R the shot goes low from the wind. However, we now have an interesting condition where the mirage is trying to lift the shot but the wind is trying to drop the shot.

So you see with one direction the lift is enhanced and with the other the lift tends to get cancelled out. The sideways movement of the bullet is about the same for both conditions.

Fig 5 demonstrates the effect we are talking about.

So beware. The POI is NOT the same elevation for both L and R mirage conditions and a bit of wind!

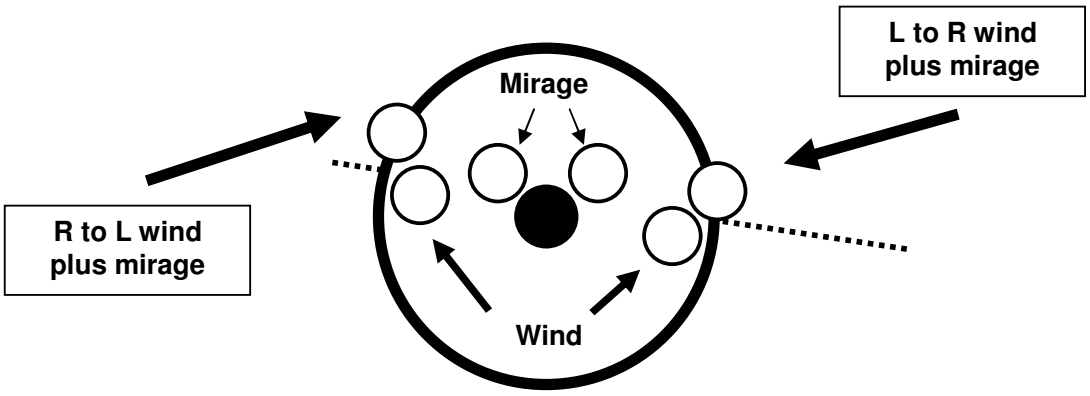


Fig 5 Difference in elevation POI from combination of Mirage and Wind.
The circle and black dot are indicators only, not a bull or scoring ring.

When considering where you might change the emphasis from mirage to taking into account just the wind, then I would consider that to be when the flag is lifting smoothly and just

beginning to flick (No 4 on the list). Below that point it is wise to consider the effect of mirage and more importantly, to watch the effect and amount of air movement using you scope rather than rely solely on the flags.

Some shooters deliberately wait until the mirage gets “blown away”. That is, the wind overcomes the effect of the mirage and a more predictable condition emerges. If conditions allow you to wait and are frequent enough then it can be a safer route.

If there are sunny patches just remember that you will need to re zero the rifle if the mirage disappears but make sure you still watch for the wind effects. Remember to stop and reconsider your actions if the sun comes out again.

Mirage is an extremely powerful and useful tool to have in your arsenal. But it certainly needs care to glean the best from it.

Equipment and Preparation

A hat or peak. The contrast between the sky and the back sights can be high. The bright sky influences the eyes pupil significantly. By shading the sky with a peak or hat, it enhances the view through the sights and keeps your eyes more relaxed. Read the ISSF rules about hats and side blinder dimensions. *Recommended!*

Filters on the back sight. On bright days it is worth gold to have a neutral density filter in the back sight. When the sun shines directly on the target - and especially from behind the shooter, the light reflected off the white of the target overpowers the retina in the eye and burns the image into the eye. Make sure you get one with at least 2 shades of grey. Polarisers are another option. Use one polariser to act as a neutral density filter or to see if there is polarised reflections off the target. Rotate it for best contrast. If you need more blocking bring the other one in at the same angle and then rotate that one until it darkens sufficiently. Leave the first one where it is and just rotate the other. *Essential!*

Non-Aiming Eye Blinder: Some of you will be able to shoot with the non aiming eye open. Most of you may not. A full blinder means you cannot view the flags and anyway it probably breaks the ISSF rules. Make one that is a vertical strip that just blocks the target from the non-aiming eye. I have found a 10 mm strong magnet perfect for holding it on the rifle sights. Or you can put the blinder on your shooting glasses. *Recommended!*

Shooting Mat. A good comfortable mat is great. You are allowed up to 50mm thick. Most in NZ are too thin. It does increase elbow comfort if they are a bit thicker. Make sure the elbow areas are covered with a soft non slip rubber. They are also good to use to align yourself on the target. There is no rule against putting marks on the mat to align with the target. If a range supplies the mat then use them as it will give you experience of different mats. In international shooting you HAVE to use the supplied mat.

Clock. A non-beeping clock (see ISSF rules) is useful to keep time out of the equation. Running out of time is stressful. Budget your time wisely. Rule of thumb: 10 minutes for sighters, 1 minute per shot, this leaves 5 minutes up your sleeve for contingencies.

Bullets. Some swear by using them straight out of the box. Some use a block. Which ever you decide the one golden rule you must follow is: ***Keep your counters separate from all other ammunition and when you start the match move all other ammunition away from the counters***. If you need to go back to sighters due to a breakdown or stoppage, then again, separate the counters until you start again. See the ISSF rules re too many shots on targets. Points are hard enough to keep. Why throw 2 away for each extra shot? *Essential!*

Scope. There are plenty of scopes around these days that are good enough for 50 m shooting. A couple of prerequisites. 50 or 60 mm diameter objective is ideal. 20X magnification is enough for both 25 yd and 50 m shooting. If you have a choice between a zoom and a fixed eyepiece. My advice is to go for the fixed. They are still optically superior and cheaper! Don't forget a good stand. See Shooting Stuff.co.nz for a good NZ made one. *Don't skimp on the scope, they will last for years!*

Fit the gear to YOU on the mound: Bring your equipment, bullets, scope to you. Make sure things like bullets, drinks, towels and clocks are in position where the loading hand does not have to stretch to get things and the scope is in a position where you just need to turn your head to see the target. Once your position is sorted you will find you can bring the scope quite close to your arm without nudging it. Experiment on the range to find your ideal arrangement. Take time to do it properly. It is worth points galore! *Recommended!*

Hydrate, hydrate, hydrate: This means drink plenty……of water. Start a day before the match with at least 2 to 3 litres consumed over the day – not all at once! On the day sip up to 2 litres and stop about 2 – 2 1/2 hours before the start time. That gives the body time to clear before the start of the match. Lying down for 75 minutes or 3 hours lying, standing and kneeling consumes water and your eyesight is the first to suffer from dehydration. Especially if it is hot, sip regularly through the match. Experiment to find out how long your body needs to clear after drinking on the day of the match. Again, being hydrated will save you **many** points. *Highly recommended!*

Rain: It will rain when you shoot…guaranteed! Other than not seeing the target if there is too much, rain can be useful. Watching the angle of the rain gives you information about wind direction and strength. Remember the flags will be heavy and unresponsive. And don't worry about a bullet hitting a rain drop. There is only about one drop in a volume 10 x 10 cm and 50 m long when it is raining at a rate of up to 4mm per hour! You are unlikely to hit one.

Keep a diary: If you do nothing else with it, copy down rifle and equipment settings. If you do next to nothing with it, copy down any tricks that you have discovered that really work for you. If you want to write more, feel free but always record, analyse and finish with what you are going to do next time to make you better. A diary with scores only in it is next to useless. A diary with a diagram of close bulls, non-bulls and the good things you did will allow you to pick up regular errors that can be corrected and reinforces the good things that work.

And don't forget to read it at least the day before so that you are ready to try the next game plan you decided last week would improve your shooting. *Highly recommended!*

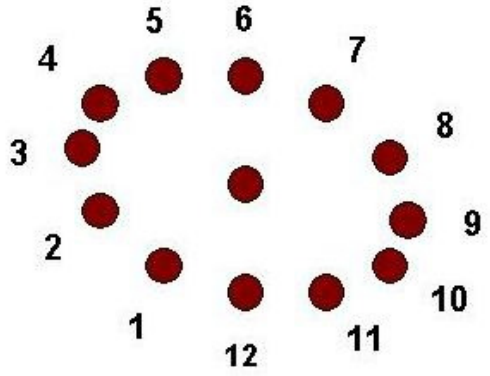


Diagram 2
Bullet POI in wind from indicated direction