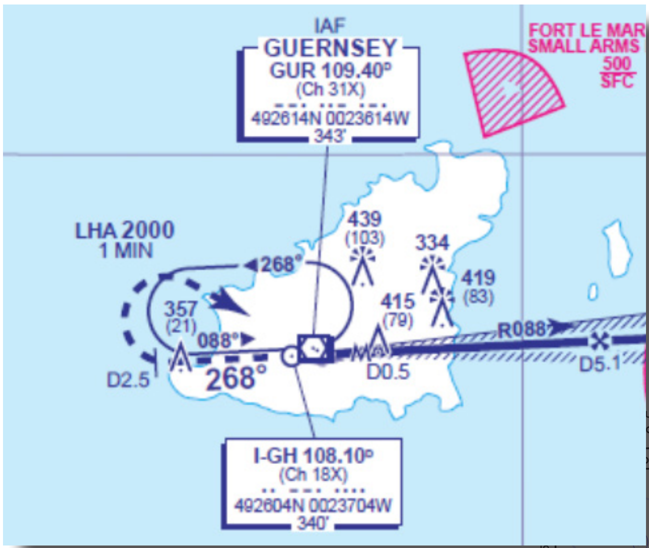
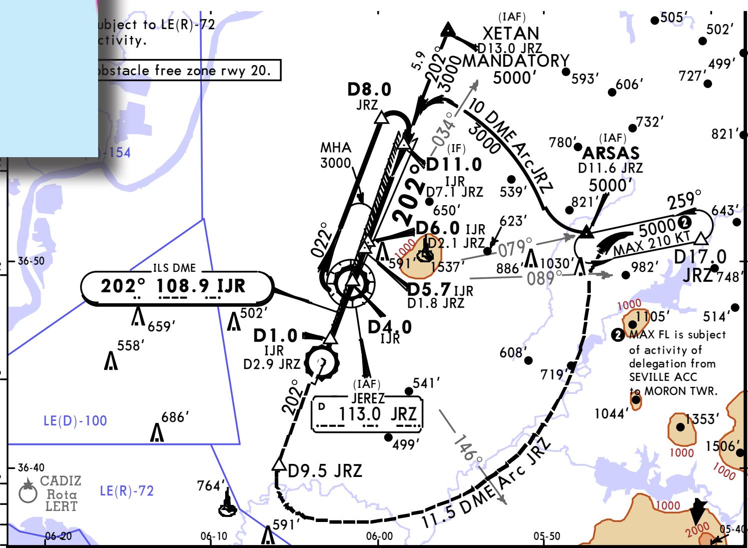
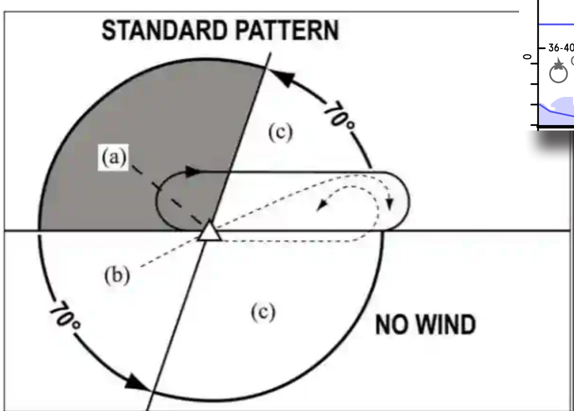
Student Study Guide

A Practical Approach to Flying Holds

Stephen R.S. Evans







EvansAbove !

HOLDS

*"Everything you ever needed to know about Holds, but were too afraid to Ask" **

Introduction
This is Part 4 in a 6-part series. If it has been some time since you read the notes on Single-Needle Tracking (Part 3), then it might be best to revise them now.

The purpose of these Student notes is not to tell you what a Hold is, but rather the practical way to enter and fly them. You should already know about the structure of an ICAO Hold, because you have passed your EASA exams.
But what that training material does not teach you, is the best way to actually fly them and make corrections in real time, under pressure and with basic instruments.

The Hold
There are three types of Hold, a Terminal or beacon-based Hold, an en-route Hold and an add-hoc Hold where you may get asked by ATC to Hold at your current position.

All Holds consists of 4 segments, based upon a "Fix" and an inbound track.

- The Fix maybe a radio beacon, such as the Sevilla VOR, "SVL" or the Jerez NDB "JER".
- It can be a RNAV Waypoint defined by a radial or distance from a VOR/DME (eg "TENDU", SVL270/13)
- A GNSS waypoint, (e.g. "KUBAS" N36.xxE060.yy), or
- You may simply be asked by ATC to "*FIS63, Hold at current position until advised*", the FIX now becomes your current position, and the inbound track, your current heading.

Hold Segments
Shown here is a Hold based upon a the JER NDB, with an Inbound track of 202º. This Hold is a "Standard Hold", and so therefore is flown clockwise with right-hand turns throughout.
A non-standard Left-hand has a turn to the left at the Fix and is an anti-clockwise circuit. It is effectively a mirror image of a Right-hand Hold.

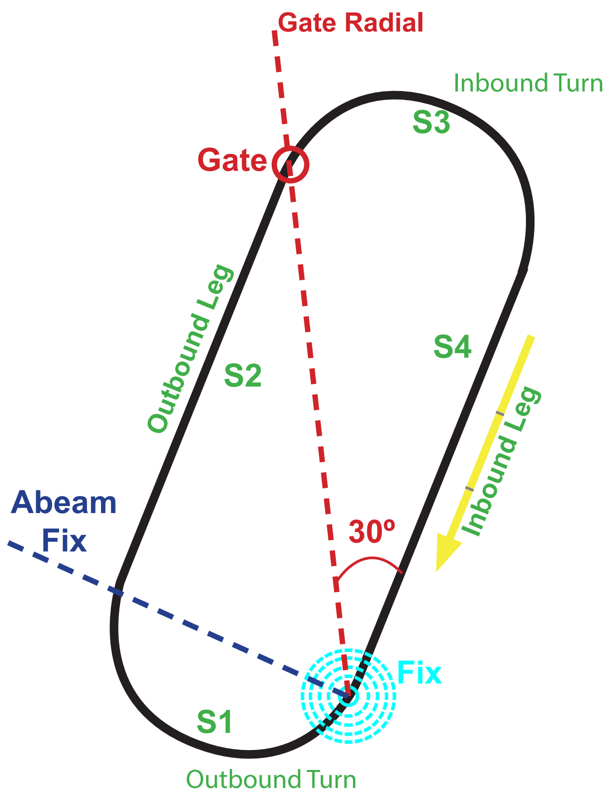
The Hold starts at the Beacon with a 180º, Rate-one turn, the is called the "Outbound Turn". All turns under Applied-IF are Rate-one. So the Outbound Turn takes 60 seconds to complete and here is shown as S1.

The second segment, S2, is called the "Outbound leg" and is flown for 1 minute. S3 is the Inbound Turn, again at Rate-One, for 60 seconds, finishing with S4, the Inbound Leg of 60 seconds back to the beacon. Total time, 4 minutes.

In addition there is "The Gate", which is the place where a radial, 30º offset from the Outbound leg, centred on the Fix intersects the OutBound Leg.

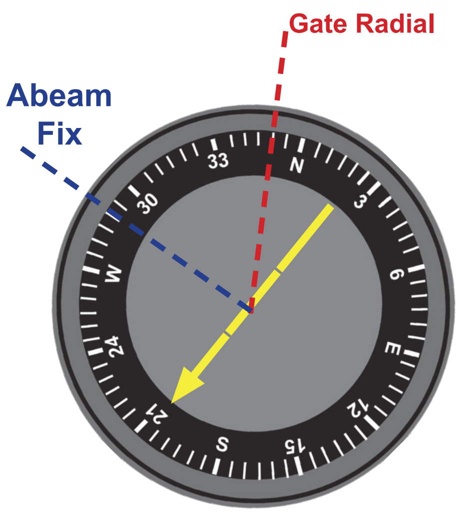
The Gate is where you commence the Inbound Turn. The importance of the Gate will become apparent later when it reaches almost mythical importance.

Lastly there is the "Abeam Fix", again a radial from the Fix and offset 90º from the Inbound Track. It is used for timing purposes.



Hold Structure

To be able to fly the Hold with the least amount of effort, you need to know the Inbound & Outbound Track and the radial of the Gate and Abeam fix.
You have a choice, the easy way and the hard way. The hard way is to do all the maths in your head, whilst in IMC at 140Kts, in turbulence, icing and whilst carrying out your descent checks, talking to ATC and maintaining a QDM to the fix within 5º tolerances.
Or you can do the following.



On your HSI, rotate the CDI so that it aligns with the Inbound track. Where is the Inbound Track? It's on the Approach Plate !

On the diagram on the left, the CDI has been set to 202º and the plane is on a heading of ~345º, this is the JRZ Hold at Jerez.
Now you can quickly work out using the CDI as a graphical calculator the following pieces of information:

IT: **Inbound track** (taken off the approach plate)
OT: **Outbound track**, from the "tail" of the CDI, e.g. 022º
Gt: **Gate**: the tail of the CDI, minus 30º, e.g. 022º - 30º = 352º
Ab: **Abeam Fix**, the head of the CDI, plus 90, so e.g. 202+90=292º
OT: **Outbound Heading**, the heading to fly to correct for Wind Drift
OT: **Outbound Timing**, the time to fly to compensate for wind

On your Pilots kneeboard , you can have an area prepared, so you can quickly jot down the 6 pieces of Hold data you need, ready for use.

IT:202 - R
OT:022
Gt:359
Ab:292
OH:013
OT:68

On the right is an example of this format. You can either make one yourself for the cockpit or use one of the ready made PLOG's available.

All of this information can be easily plucked off of the compass rose of the HSI once the CDI has been aligned with the Inbound track given to you by the Approach Plate.
No mental arithmetic, quick and easy.
As for calculating Oh and Ot, this will be covered later.

Hold Entries

There are technically 3 types of hold entry
- Parallel
- Offset / Teardrop
- Direct

Of which there three sub-species of Direct Hold entry
- Less than 90º
- 90º to 180º, and
- Greater than 180º

In reality, rather than there being 5 hold possible entries, there are actually only 4, as the Direct:<90º is actually flown the same as an Offset, which we explain later.

Hold Sectors

The Hold can be approached from anywhere within 360º of the Fix.

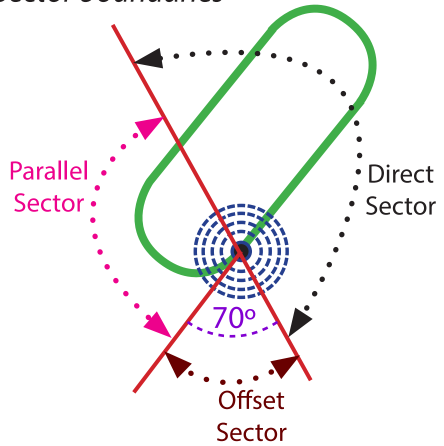
To facilitate aircraft separation and terrain clearance, 3 hold entries are defined.

The decision on which hold entry to used is based upon which sector the Aircraft is approaching the Fix, based on the Heading (not the track) of the aircraft.

There is a 5º margin of latitude at the edges of each Entry segment which the pilot can choose to use.

Using the example above where the Outbound track of the Hold is 022º, if the aircraft is _Heading_ between 017º and 027º, then the

70º Offset from Inbound Track sets the Sector boundaries



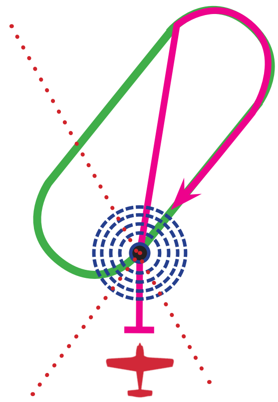
pilot could choose to fly either the Parallel or Offset entry.

It should be noted, that if (for example) there was a strong southerly wind for this 202º Hold, and the aircraft was _Tracking_ towards the Beacon at 022º, but had a Wind-corrected _Heading_ of (say) 030º, the Pilot would have no choice but to choose a Parallel Entry. This is because entry is based on Heading not Track.

Applied IF Basics

Before describing how to fly Holds, it worth taking some time to quickly revise the concepts behind Single-needle tracking.

When using an RMI or an RBI to track a QDM, then you need to "Push the Head" of the needle. If tracking a QDR, then you need to "Pull the Tail" of the needle. If this concept is familiar, carry on. If QDM/QDR/RMI or RBI are unfamiliar, please revise the Student notes on Single Needle Tracking & Interception as part of this series of Student notes.

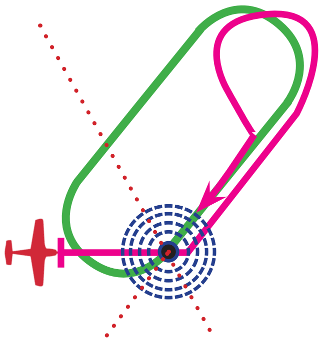


The Offset Entry

Sometimes also called the "teardrop" due to the path the aircraft takes in joining the hold.

The idea is to fly to the Gate, for a period of 1 minute before turning back towards the Beacon / Fix.

The second time over the Beacon / Fix, you are actually entering the Hold, hence why this is called an "indirect entry".



The Parallel Entry

Directly track towards the Fix. After passing the Fix, start to turn towards the Outbound Track, in parallel with the Inbound track. After 1 minute Outbound turn left aprox 240º to set up a 60º intercept to the Inbound track.

Anticipate and intercept the Inbound Track to the Beacon. The second time over the Beacon / Fix, you are actually entering the Hold, also an "indirect entry".

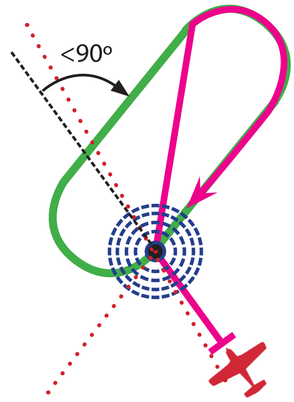
Direct Entry

As stated earlier there are 3 types of Direct Entry.

- Less than 90º
- 90ºto 180º
- Greater than 180º

The Names refer to the number of degrees you must turn through once you have passed the beacon in order to fly the Outbound Leg.

The diagrams on the right illustrate the different types of Direct entry.



Direct Hold <90º

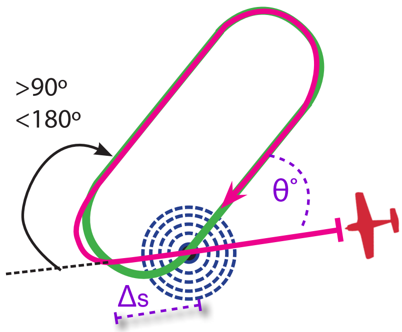
Direct <90º (*Pronounced "Direct less than 90"*)
In a Direct Less than 90 degrees entry, the aircraft starts a turn about 0.5nm before the beacon and turns to intercept the Gate radial. The aim is to be at the Gate at the end of 1 minute.
Note that is the same technique as an Offset entry. For this reason the *Direct <90º* and the *Offset Entry* can be consider the same. Hence the explanation at the beginning of this document that there are effectively only 4 different Hold Entries.

Direct >90º <180º (*Pronounced "Direct greater than 90"*)
The aircraft passes over the Fix. Then continues in a straight line for Δ (delta) Seconds, before turning towards and flying along the Outbound leg until reaching the Gate.

The number of Seconds to fly depends upon θ (theta), which is the angle between the track towards the Fix and the Inbound track. The equation is:

$$\Delta = \theta / 5$$

it does not have to be über-accurate, just approximate.



Direct Hold >90º <180º

For example, if the Inbound Leg is 202˚ and the aircraft Heading (not track) to the Fix is 230˚, then θ is ≈30˚, so 30÷5=6, so Δ is 6 seconds.

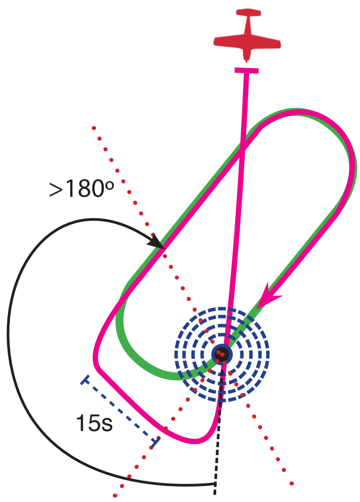
Therefore once you have passed the fix, you continue flying for 6 seconds on a heading of 230º before turning towards the Outbound leg of 022˚. Upon reaching the Gate QDR, start the Inbound turn to the Inbound track Leg.

The number of seconds to fly straight, Δ, should be limited to 15seconds. So if θ was 80˚, Δ <u>should be</u> 16 seconds, but we actually limit Δ to 15seconds.

Direct >180˚ (*Pronounced "Direct greater than 180"*)
With this Entry, you fly over the Fix, and turn towards the same radial as the Abeam Fix. On crossing the Inbound radial, fly for 15seconds before turning towards the Outbound track, then turn back towards the Fix at the Gate.

In our example of the JER LEJR Hold with a 202˚ Inbound track, once overhead the Fix, turn right to 292˚ and parallel the Abeam Fix radial of 292˚.

On passing the QDR of 202˚ (by GNSS or RBI/RMI), fly the 292˚track for 15seconds, then turn right onto 022˚ until reaching the Gate QDR of 352˚. Upon reaching the Gate QDR, start the Inbound turn to the Inbound track Leg.



Direct Entry >180º

When approaching the Hold, you need to decide which Hold entry is appropriate. There are several methods available, we shall discuss the "POD" and "Visual Overlay" methods, both of which are visual and quick.

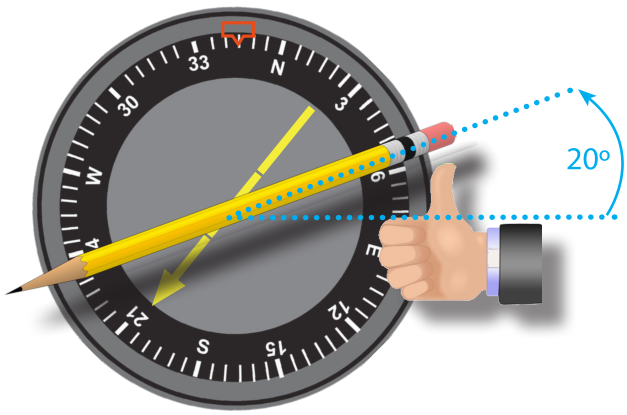
As was explained previously, start by using your HSI as a "Bug" and put the CDI on the Inbound track of the Hold. The Inbound Track can be found on the Approach Plate.

For example, the JER Hold at Jerez, the Inbound Track would be 202˚

In this example on the left, the Aircraft is heading ~345˚ .

Now imagine, or for real, laying a pencil centrally across the face of the HSI from right to left.

The pencil is now laying across the face at 070˚ - 250˚



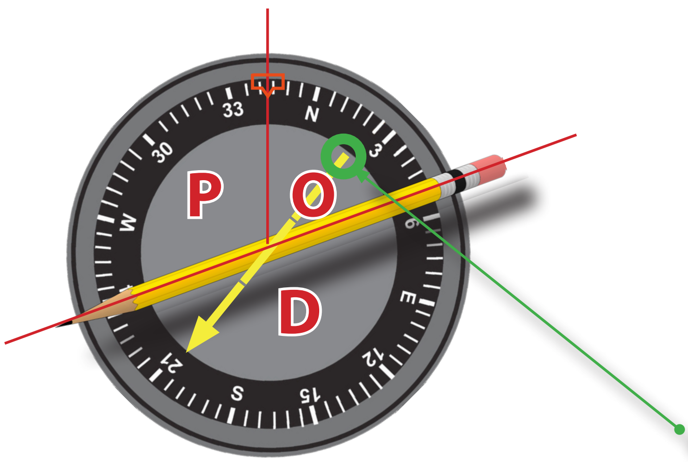
Now imagine, pushing up the back of the pencil with your right thumb by 20˚.

It is now lying 050˚ - 230˚ (as shown left).

Why 20˚?
As we are mirroring the Hold on our HSI face and the segments of all Holds are defined by a 70˚offset from the Inbound Track, then 90˚-70˚ is 20˚

Because the JER is a Right-hand standard Hold, then we use our Right-hand thumb to create the 20˚ offset.

You can now draw an imaginary line down from the top of the HSI down to the centre of the pencil, and another line across the length of the pencil. Shown here in red.



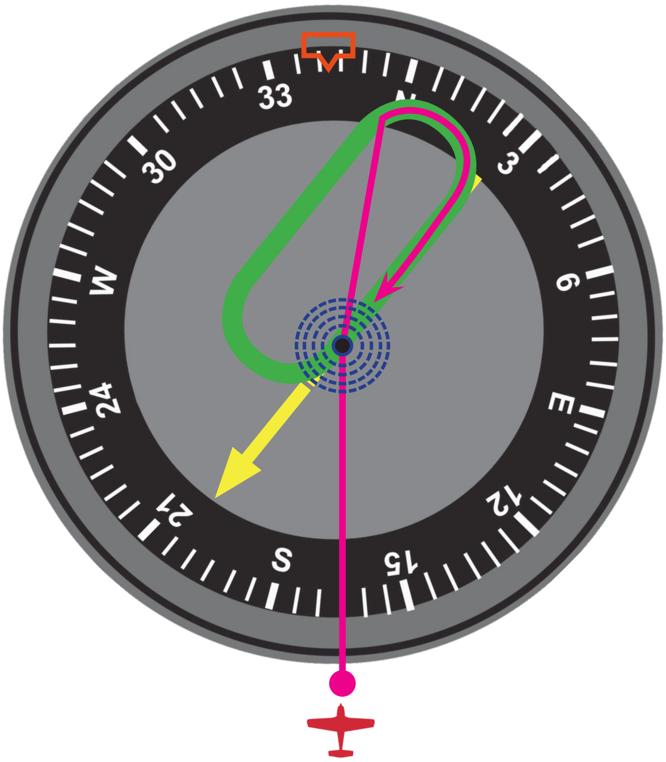
We have now split the HSI face into 3 segments.

These are "P-O-D"; Parallel, Offset and Direct sectors. The largest sector is Direct, next biggest is Parallel and the smallest is Offset.

Look the "tail" of the CDI, it is in the "O", or Offset segment.

Therefore, this is an Offset entry to a 202˚ Hold with a track towards the Beacon/Fix of 345˚.

Visual Overlay Method



Another way to visualise the Hold entry is to imagine that the beacon or Fix is in the middle of the CDI bar.

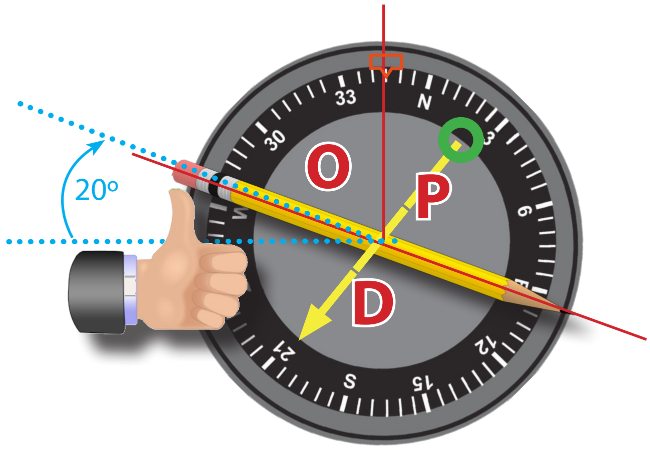
The inbound track is in the direction of the CDI arrow, which in this case is an inbound track of 202º

You can then imagine overlaying the Hold starting at the Beacon.
In this case of a Standard (right) Hold, the oval shape of the Hold pattern can be placed over the CDI arrow, shown here in green.

The aircraft is approaching the Fix from the bottom of the HSI (165˚) up towards the top.

It is now easy to visual that this is an Offset Entry

Left Hand Hold: POD & Overlay Method



In the case of a Left-handed, non-standard Hold (*such as Kubas for the LEJR RW02 approach*) then we simply use the our left thumb to lift the rear of our imaginary pencil by 20˚.

The largest sector, as before, is Direct, next biggest is Parallel and the smallest is Offset.

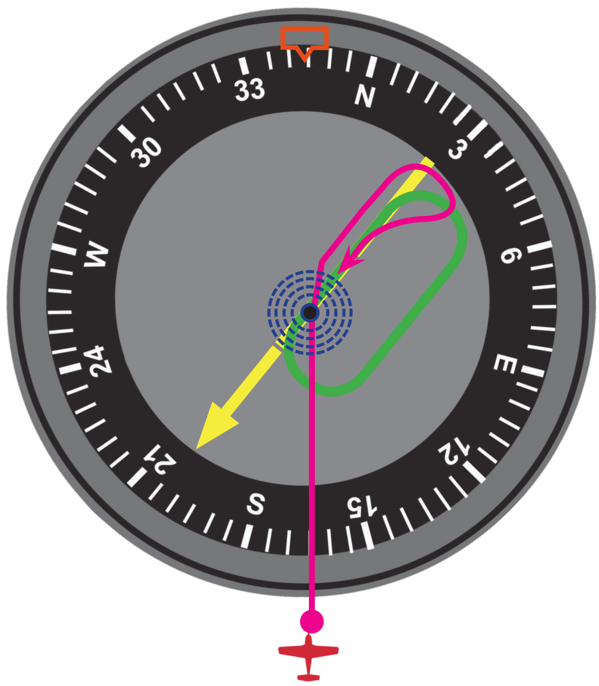
In the example on the right, with a 205˚ Inbound Track and a 345˚ heading towards the Fix, then this would be a Parallel entry as the "tail" of the CDI is in the Parallel sector.

Alternatively, using the Visual Overlay method, this same Hold can be visualised to be a Parallel entry as well.

Either method is equally valid as a system for quickly determining the Entry type for your current Heading.

Use which ever one you feel most comfortable with.

In reality, most pilots use both, as a double-check that they have made the correct choice, .

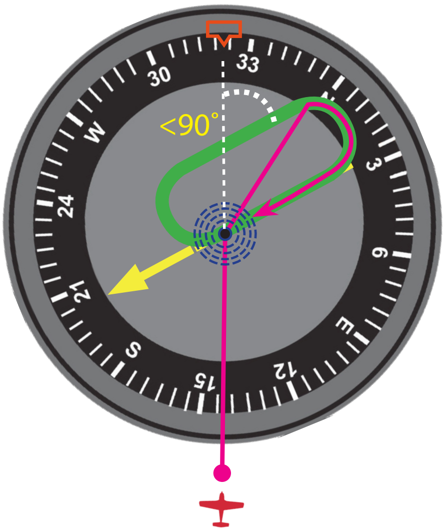


Effects of Wind

How to Interpret the Direct Hold Entries on the HSI/RMI/RBI

All of the previous images of Hold entries look fine on paper, but how to visualise them when in the air?

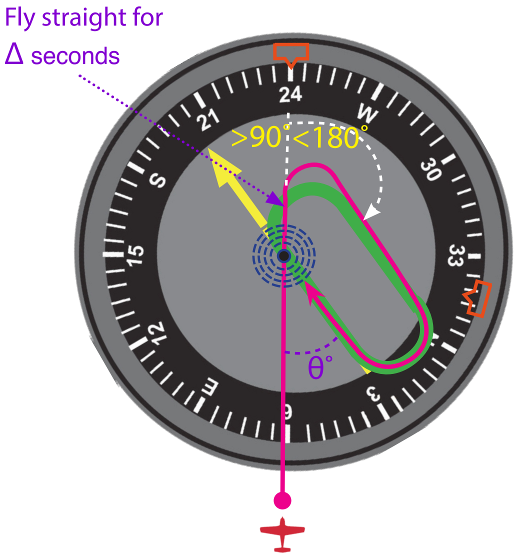
The diagrams below assume you have “bugged the Inbound leg of the Hold with your CDI. Once you have



On the left, this is the view from the cockpit as you approach a Beacon for a Direct <90˚ Hold join.

The “*less than 90˚*” comes from the fact that you will turn through less than 90˚ from the present heading onto the Outbound Track.

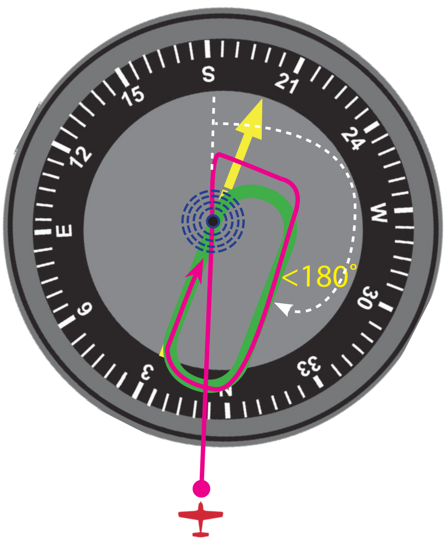
If you can imagine to superimpose the Beacon on the middle of the RMI and then the Hold in respect of the Beacon (the green line), then it is quite easy to visualise how to join this hold and which one it is.



On the left, this is the view from the cockpit as you approach a Beacon for a Direct greater than 90˚ but less than 180˚ Hold entry.

Once you have overflown the Beacon, continue on your heading for Δ seconds, (θ˚ ÷5), you then turn until you are flying along the Outbound leg. This turn will be more than 90˚, but less than 180˚.

You continue to fly out to the Gate and turn back to the Beacon at the Gate.



Using the CDI as a “bug” and imagining the Hold superimposed on top of the RMI, you can visualise the *direct greater than 180˚* entry.
You overfly the beacon and turn in the Hold direction (in this case “right”) and roll out and fly in the same direction as the Abeam Fix (*direction <u>not</u> radial*).

Once you have crossed the Inbound QDM, continue the Abeam Fix track for 15 seconds then turn again to intercept the Outbound leg. This in effect means that you make two turns, the sum of which will be greater than 180˚ in total.

You continue to fly out to the Gate and turn back to the Beacon at the Gate.

Flying an accurate Hold in a simulator with no wind is relatively straightforward. When you do it for real, in IMC conditions, turbulence and windy conditions, its a *whole new ball game*.

Wind correction for a Hold does not require a CRP-5, or any other calculator, just some fast, simple mental arithmatic.
DO not make the mistake of trying to look-up the wind on the ground before you fly and then plan with precise detail the Hold, corrections and drift angles, because the wind changes speed and direction in real-time and is highly unlikely to be as forecast, ore reported and in addition you may be forced by ATC to climb to unplanned altitudes where the wind is different again. It is much better to be able to calculate on-the-fly.

What you need is a method that is quick, intuitive and proportional.

So lets have a look at calculating Single Drift.

Maximum Drift Speed: MDS

Max Drift Speed is the maximum speed at which the wind will drift you from your intended track over the ground, which is undesirable when you want to be flying a QDR or a QDM to within 5˚.

The MDS is given by the equation:

MDS = 60÷TAS x Wind Velocity

Can you do this in your head, with say, 87 Knots of TAS?

Don't bother, you don't need to.

Imagine an old Biplane, it flies along at **60**Kts. Then its MDS is simply equal to the Wind Velocity (WV)

60 ÷ **60** x WV = 1 x WV

Now imagine a Seneca flying along at **120**Kts, then the MDS will be equal to half of the WV

60 ÷ **120** x WV = 0.5 x WV

When the Wind Velocity is less than 5% of the airspeed of the aircraft, you can pretty much ignore wind drift. This is because 5% equates to a maximum wind drift of ~3˚ which is the limit of the accuracy that most humans can fly at.

This is unless you are flying for more than 1 hour on a fixed heading, in which case you should recalculate every 45 minutes

Autopilots are much better and can achieve +/- 1˚ accuracy but given that most winds are variable in any case, wind speed of 5% of TAS and below is below the threshold where it can be safely ignored, but should still be monitored.

So if you are flying a Cessna172 or a WarriorPA28, which cruises at 90Kts, then the MDS will be half-way between the above two examples.

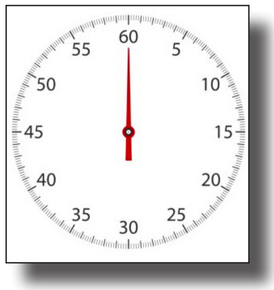
So by way of example, lets take a wind of 20Kts, the MDS for each aircraft will be:

•Biplane: 60÷**60** x 20Kts WV = 20Kts Max Drift Speed
•Seneca: 60÷**120** x 20Kts WV = 10Kts Max Drift Speed

So logically a PA28/C172 at 90Kts will have a MDS of 15Kts, half-way between 10 and 20!
And in fact, as a C172/PA28 will typically cruise at 100/105Kts, just knock off 1Kt of MDS of 15 giving you a final figure of approximately 14Kts.

As the wind will vary, your guestimate will be good enough for real-world flying. What we are looking for is an answer that is quick, close enough and doesn't get in the way of flying the aircraft.

Try this method with a wind of 25Kts, then 14Kts, and then compare your mental calculations with the answer from a calculator. You will be surprised.



So now we know MDS, we can now work out our Single Drift Correction Angle for any given heading, enter another simple method, enter the "Clock Code"

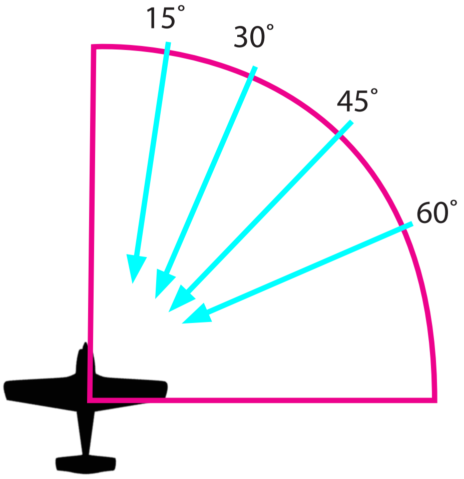
The Clock Code and the Wind Drift

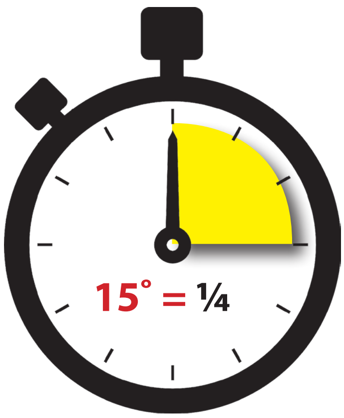
The Clock Code is a quick and simple way to calculate the Wind Drift (and therefore the Wind Correction Angle) for a given MDS and a heading.

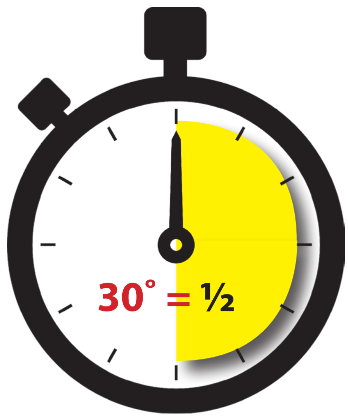
The mathematical way of doing this involves the Sine of the angle between the heading and wind direction multiplied by the MDS.

Want to get your Sine tables out, mid flight? No? thought not !.........
Now imagine a Stopwatch face marked in seconds. Wait ! Maybe take a look at the watch on your wrist.

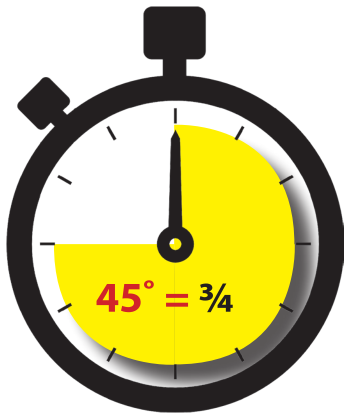
If it is "old school" analogue, you don't have to imagine it, you already have a clock calculator on your arm!







Maybe now you will start to understand why real IR Pilots wear analogue watches! Maybe time to think about treating yourself to a new watch? Whilst you are at it make sure it has a Stopwatch or at least a second hand. More on this later.

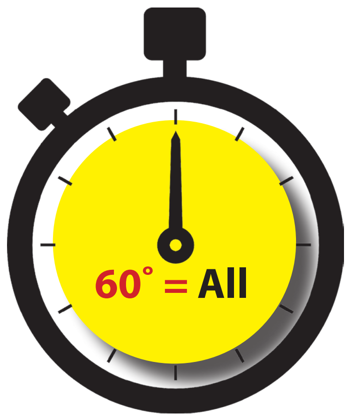


So, split the face into 15 second quarters, that is from 0 to 15, 15 to 30, 30 to 45 and 45 to 60s.

Then take the approximate number of degrees the wind is coming from **in relation to the heading of the aircraft**.

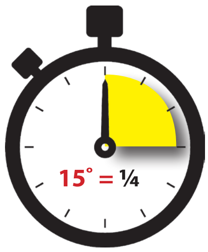
Now convert the number of degrees to the number of seconds around the Stopwatch face and break the face in sectors..

- 15˚ is 15 seconds, which is a ¼ of the way around the face, so this is the *"¼ Sector"*
- 30˚ is 30 seconds, which is a ½ of the way around the face, so this is the *"½ Sector"*.
- 45˚ is 45 seconds, which is a ¾ of the way around the face and finally for 60˚and above to 90˚, is 100% of the way around the stopwatch face.



To work out the wind drift, find which sector the wind is coming from, then multiply the MDS by the angular fraction of the Sector.

Example #1.



Aircraft heading North (360˚ / 0˚), MDS is 10Kts at 012˚, what is its Track?
The wind is 12º to the right of the nose of the aircraft and therefore is in the ¼ Sector.

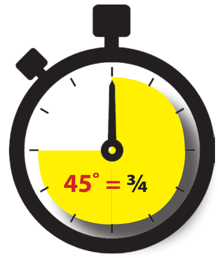
Using Clock Code, Wind Drift is: **¼ x 12˚ =3˚** of wind drift to the left so the aircraft is drifting to the left on a Track Over Ground ("TOG") of 357˚ (360˚ - 3˚).

Example #2.
Aircraft heading 120˚ (south east), MDS is 15Kts at 080˚. What is the wind drift & TOG?

The wind is 40˚to the left of the nose of the Aircraft, 40º is in the ¾ Sector.

Using Clock Code, the Wind Drift is: **¾ x 15˚ =10˚**

Therefore there is a wind drift of 10˚ to the right, so the aircraft is being blown off the desired track by ≈10˚, so our Track over the Ground ("TOG") is 120+10 ≈ 130˚



Putting It All Together and how to Fix It

So now we have learnt how to calculate the Maximum Drift Speed MDS, and we can now use the clock code to work out the wind drift for any direction the aircraft wants to fly.
To do this we need the Wind Correction Angle "WCA" to fly to correct for and compensate for, the wind drift.

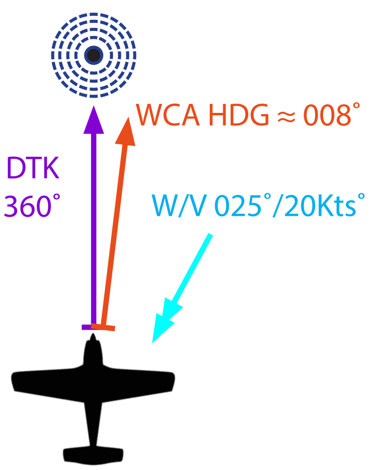
"WCA" and "Single Drift" are essentially the same, but WCA is used more when talking about en-route flying, and the term Single Drift is used specifically with regard to the Inbound and Outbound headings used in a Hold. They are the same number and calculated the same way.

The idea is that when you are tracking towards a Beacon, or a Fix, or flying Inbound on the Hold, you need to fly a Wind Corrected Angle to offset the effect of the wind drifting you to the left or right of the published track. Why is this important? Terrain clearance and Aircraft separation.

If you do not, you will effectively be "homing" to the Beacon. Do this on test and you can expect to fail your IR Skills Test, burn through precious fuel and demonstrate your poor piloting skills. Your Single Needle Skills Test tracking limit is +/-5˚of Track.

This may seem complicated at first, but once you get your head around it, it is ludicrously simple.
Here come lots of examples with pictures.

Example A:
A Cessna 172 is tracking towards a Beacon from the south on a Desired Track ("DTK") of 360˚at 90Kts TAS. The wind and velocity ("W/V") is 025˚at 20Kts.



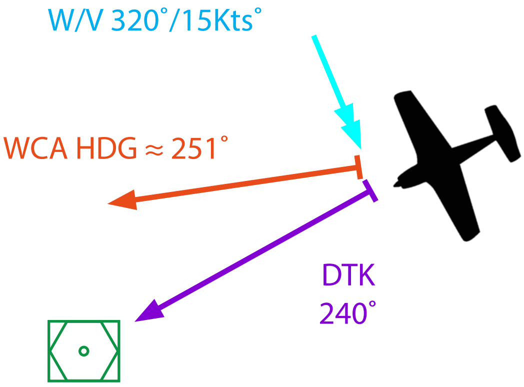
What heading should the pilot take to continue to track towards the beacon on a QDM of 360˚?

MDS first:
20Kts for Biplane, 10Kts for Seneca, so 15Kts MDS for C172 at 90Kts.

WCA next:
Track is 000˚, W/V is 025º, so 25˚ to the right of the nose.
Look at your watch, 25 is in the ½ Sector, so MDS of 15 x ½ ≈ 8˚, so
WCA is 360/000˚ + 8= 008˚ (as we need to steer to the right to counteract the wind)

So a Heading of 008˚will keep the aircraft Tracking to the Beacon on a DTK of 360˚.
This is the Wind Corrected Angle WCA, or Single Drift if describing a Hold.

Example B:
An PA28 with a TAS of 105Kts has to track inbound to a VOR on a DTK of 240˚



estimated Wind is 320˚/ 15Kts

What is the WCA and HDG to steer to maintain the QDM of 240˚ to the VOR?

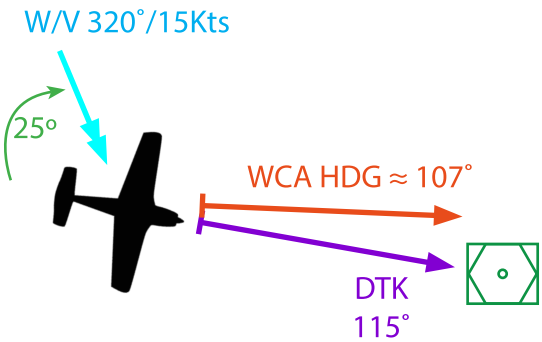
MDS first:
15Kts for Biplane, 8Kts for Seneca, so at 90Kts 12Kts, so at 105, call it 11Kts.

WCA next: (use your HSI to calculate the wind difference)
Track is 240˚, W/V is 320º, so 80˚ to the right of the nose.
Look at your watch, 80 is above 60, so take all the drift of 11˚, so
WCA is 240˚ + 11= 251˚
(as we need to steer to the right to counteract the wind from the right)

So a Heading of 251˚will keep the aircraft Tracking to the Beacon on a DTK of 240˚. This the Wind Corrected Angle WCA and HDG to steer of 251˚.

Example C:
An C150 with a TAS of 80Kts has to track inbound to a VOR on a DTK/QDM of 115˚, estimated Wind is 320˚/ 15Kts

What is the WCA to steer to maintain the QDM of 115˚ to the VOR?



MDS first:
15Kts for Biplane, 8Kts for Seneca, so at 90Kts 12Kts, so at 80Kts, call it 13Kts.

WCA next:
(*use your HSI to visually calculate the wind difference, see diagram below*)
Track is 115˚ (the QDM), the QDR is 295˚
W/V is 320º - 295˚ is 25˚ so wind is coming from 25˚ to the left of the tail.

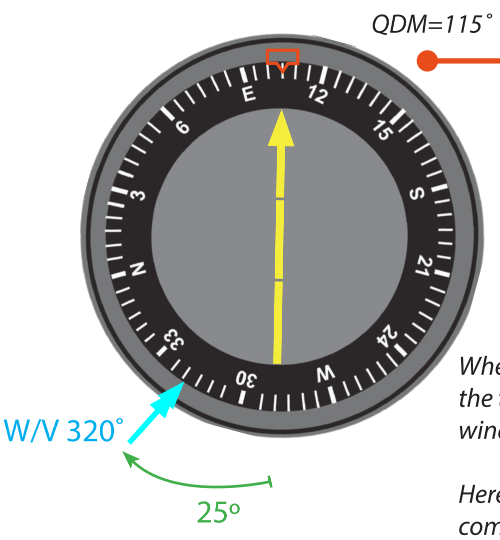
Look at your watch, 25 is inside the ½ sector, so half of the drift of 13, gives a drift of ≈7˚ to the right, so steer 7˚ to the left to counteract it

Therefore WCA is 115˚ - 7= 108˚

So a Heading of 108˚will keep the aircraft Tracking to the Beacon on a DTK of 115˚. This the Wind Corrected Angle WCA and HDG to steer for 115˚.

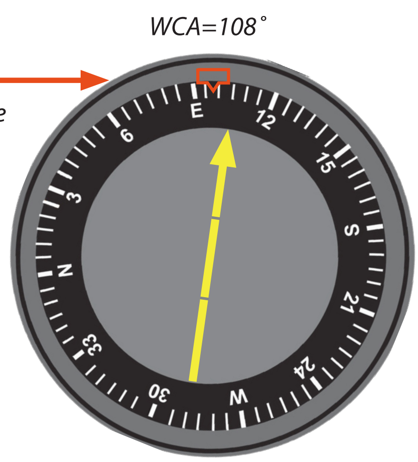
To finish off the correction, move the Heading bug on the HSI from 115˚ as shown on the left hand diagram to 108˚ as shown on the right.

Then fly, *wait for it*, 108˚ and stay in the bug!



Once you have calculated the WCA, set it on the Heading Bug and fly it !

This way you will track to the Beacon, not "Home" to it.



When the wind is from behind you, use the tail of the CDI to visually estimate the wind difference angle.

Here the QDR is 295˚, and the wind is coming from 320˚ so 25˚ difference

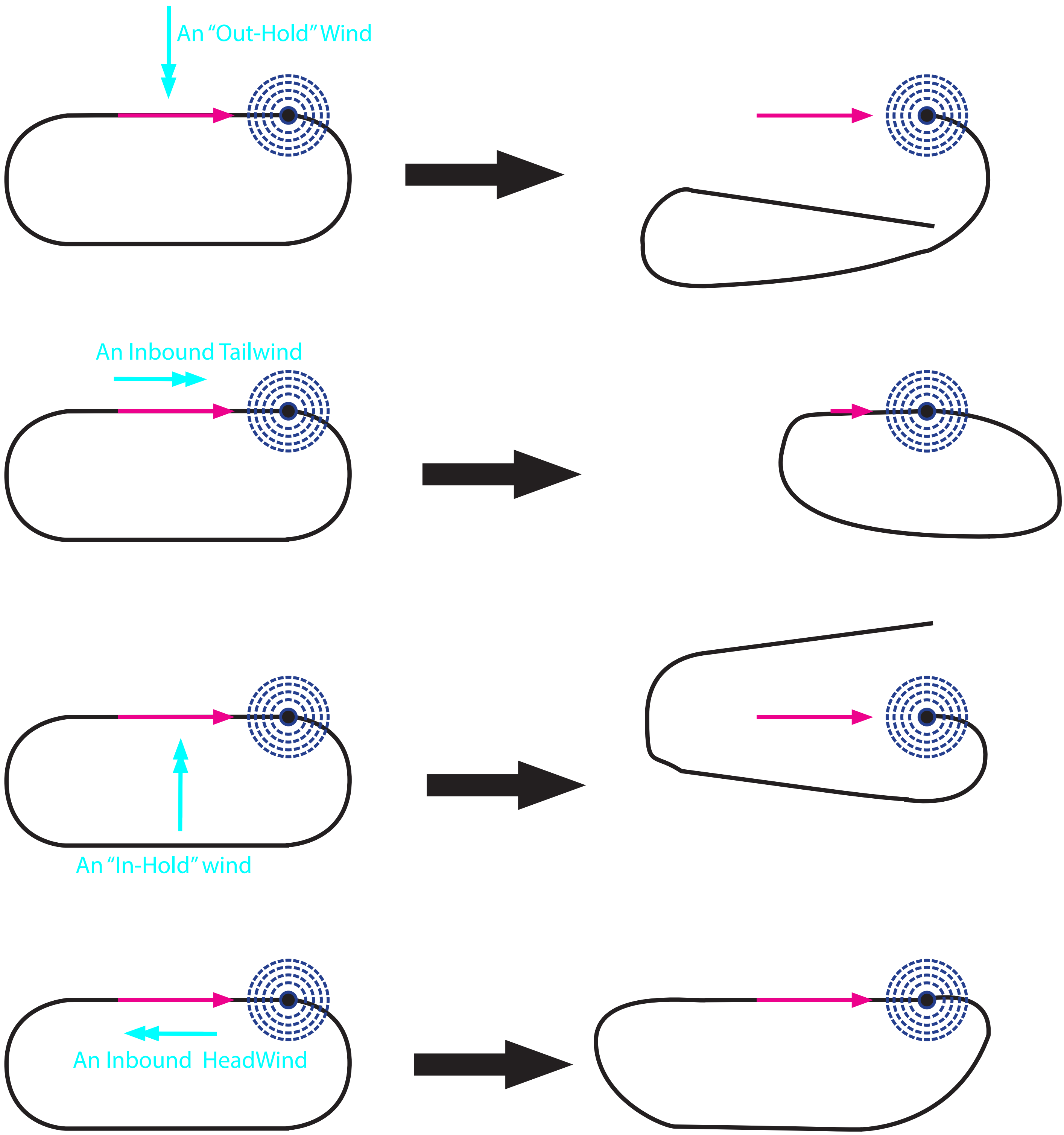
Wind Correction in the Hold

Holds are rarely flown with zero wind, and as a result if no correction is made for the wind, then the tracks flown may outside of terrain and collision avoidance limits presenting a danger to the aircraft, or even other separation from other aircraft.

There are several steps you can take to compensate for wind drift in the hold to either completely compensate for the wind, or at worst, limit its effect.

Before we look at the mitigation, lets take a look at the effect of wind on the shape of a standard Hold. The diagram on the left is the standard hold shape with no wind applied, the diagram on the right is what happens when no wind correction is made for the wind shown.

The diagrams are exaggerated for clarity, but some students have in the past actually flown them like this !



On-Axis Headwinds and Tailwinds

These are the easiest to deal with as there is a simple equation for correcting for the wind.

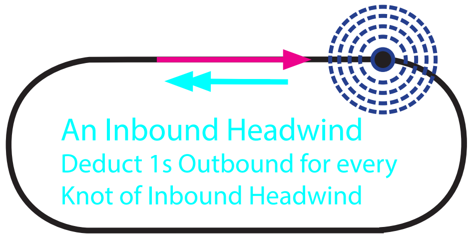
1 Knot wind = 1second of correction

The starting point to understanding this is that the Hold must be flown at constant speed and all turns must be flown at rate one.

That is 3˚per second or constant Bank Angle. { (TAS÷10) + 7) } eg 120Kts- 1

As both of the turns are rate one, that means a with constant bank angle. Therefore you cannot correct for the wind in the turn.

By the time you have flown around the Inbound Turn, it too late to make any correction as you can't shorten the leg by speeding up, and you can't shorten by distance as you have to fly over the Beacon.



This means there is only one segment of the Hold where an adjustment can be made. This is the Outbound leg. The only solution is to fly the Outbound leg according to the correction.

Example 1: If there is an Outbound Headwind of 5Knots, extend the Outbound Leg for an extra 5seconds,

That is **60s + 5s = 65 seconds Outbound** before turning at the Gate to the Inbound Turn**.**

Example 2: Similarly, if there is an Outbound Tailwind, you can compensate by deducting the number of seconds equivalent to the Windspeed from the Outbound Leg, so using the same example above

That is **60s - 5s = 55 seconds Outbound** before turning at the Gate to the Inbound Turn

Compensation for other Headwinds and Tailwinds

If the Headwind or Tailwind is not exactly aligned with the Hold axis, we must make an adjustment to the simple equation of 1KT = 1second.

This is where a variation of the Clock Code can come in. As with Wind Correction angle it is an approximation, but it is accurate enough for our purposes.

Start by the approximate number of degrees the wind is coming from **in relation to the heading of the aircraft**.

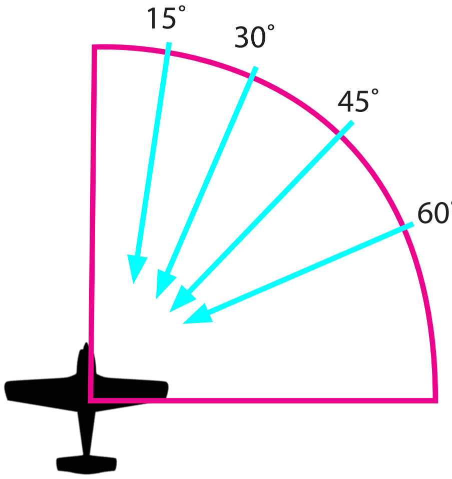
Now convert the number of degrees to the number of seconds around the Stopwatch face and break the face in sectors as we did with Maximum Drift Speed, except that this time, we work **ANTI-CLOCKWISE**:

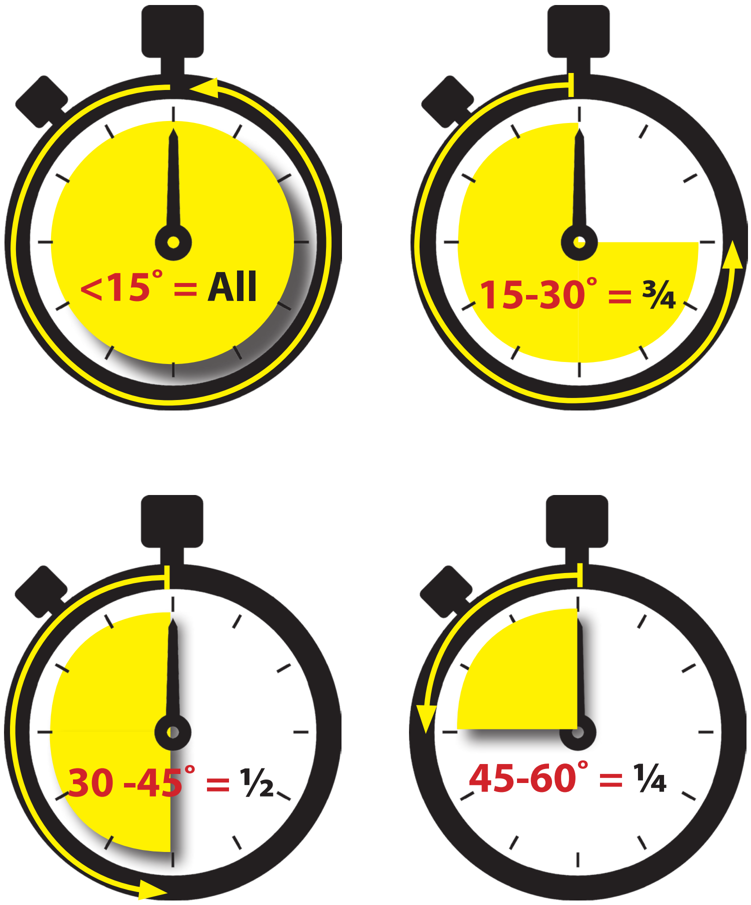
- 15˚ to 0˚, which is all of the way around the face, so this is the *"Full Sector"*
- 30˚ to 15˚, which is a ¾ of the way around the face, so this is the *"¾ Sector"*.
- 45˚ to 30˚ is which is the first ½ of the face, so this is the "½ Sector"
- 60˚ to 45˚ is the first ¼ of the way around the face, so this is the "¼ Sector"

and finally for 60˚and above to 90˚ we take zero correction for Headwind or Tailwind

Think of this way, between 0° and 15° either side of the Nose or Tail of the aircraft we take 100% of the Headwind and Tailwind and correct for that.

If the Head/Tailwind is between 15° and 30° of the nose or Tail of the aircraft, then we use ¾ of the





Stopwatch face, so we take ¾ of the Headwind / Tailwind, and so on.

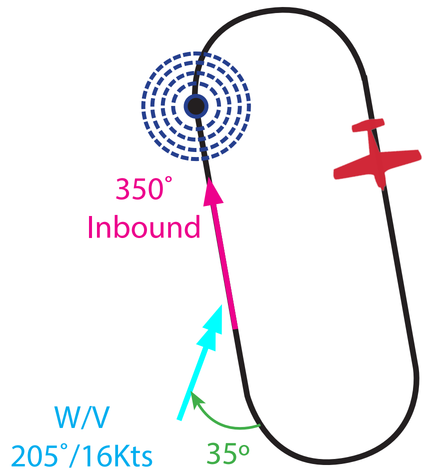
Example I
An aircraft is flying a Hold with a Inbound Track of 180°, the wind is 155°/15Kts.
What is the OutBound time Correction?

The Wind is an Inbound Headwind of 180 - 155 = 25°

25°is in the ¾ *Sector, so take*
¾ x 15 Knots = 10 Knots
1Knot wind = 1second of correction

It is a Outbound TailWind so deduct 10 seconds to the Outbound Leg
60s -10s = **50 seconds on the Outbound Leg**

Example II
An aircraft is flying a Hold with a Inbound Track of 350˚, the wind is 205˚/16Kts. What is the OutBound time Correction?



350 -> 205 is 35˚ off the Inbound Track, which is in the ½ Sector, so:

16 x ½ = 8˚ or **8 seconds correction**

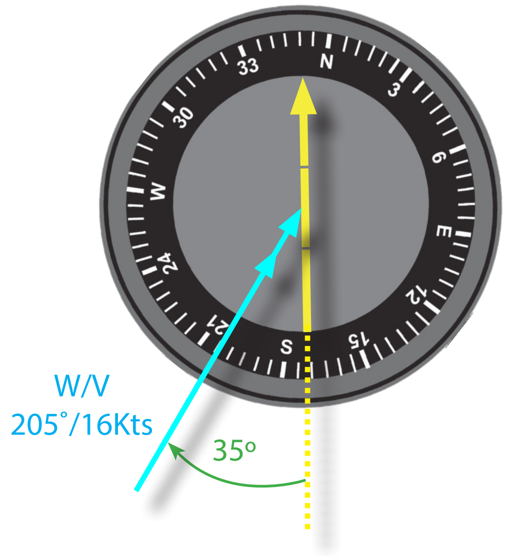
How do you quickly calculate the cross-wind angle between the Inbound track and the wind?

Use the HSI.
Once you have setup the CDI with the Inbound Leg (shown below as 350˚as in this Example II, then you can superimpose the wind coming from 205˚

It is then easy to see that the wind is an Inbound Tailwind of 35˚

As it is an Inbound Tailwind, it must by logic an Outbound Leg Headwind.

With an Outbound Headwind, we then must add 8s to 60, to get 68 seconds for the Outbound leg.



IT:202 - R
OT:022
Gt:359
Ab:292
OH:013
OT:68

Remember this Plog Planner on the left?

Now you can probably guess what the “OT” means.

It is the calculated “Outbound time” for the hold, which here is filled in with the above data for Example II of 68 seconds.

That just leaves the “Oh” field to be filled in.

“Oh” means Outbound Heading and is the heading to steer to correct for cross-Hold Winds

Cross-Hold Wind Correction

As was stated earlier, Holds must be flown at constant speed and with rate-one turns. This means that there are potentially one two legs of a Hold where the wind drift for a cross-hold wind can be compensated for; namely the Outbound and Inbound leg.

Unfortunately as the Inbound leg must terminate with a passage over the fix within 5˚of the published Inbound leg, there is no opportunity to compensate on the Inbound leg.

This leaves only the Outbound leg where any compensation can be made for cross-Hold wind drift. SO how to calculate the correction. We have already seen how to calculate Single Drift (or WCA) from a W/V and a Desired track (DTK), QDM or QDR.

How is this applied? Well we apply Single Drift to the Outbound leg, which is usually 60s long. So far so good. However we need to compensate for the drift in the Outbound turn.

As this is also 60s long (at rate-One turn of 3˚ per sec) we can compensate for the Outbound turn by adding it's drift to that of the Outbound leg, so we use twice as much Single-Drift in the Outbound leg.
But wait!, we also need to compensate for the Inbound turn, also Rate one for 180˚, so another 60s.

So add another Single drift to the Outbound leg to compensate for the Inbound turn and now we have a "Triple-Drift" on the Outbound leg to compensate for the Outbound leg itself and the two turns.

In-Hold Wind

When the wind is blowing such that an aircraft would be blown "into" the hold when flying on the Outbound leg, this is known as an "In-Hold" wind. Looking at the diagram below, the nil-wind Outbound leg would normally be 270˚ for an Inbound track of 090˚

If we take a Single-Drift WCA of 10˚ from the South (in the diagram below), then the Outbound leg would have be flown 3x 10˚ = 30º to compensate for the wind from the south.

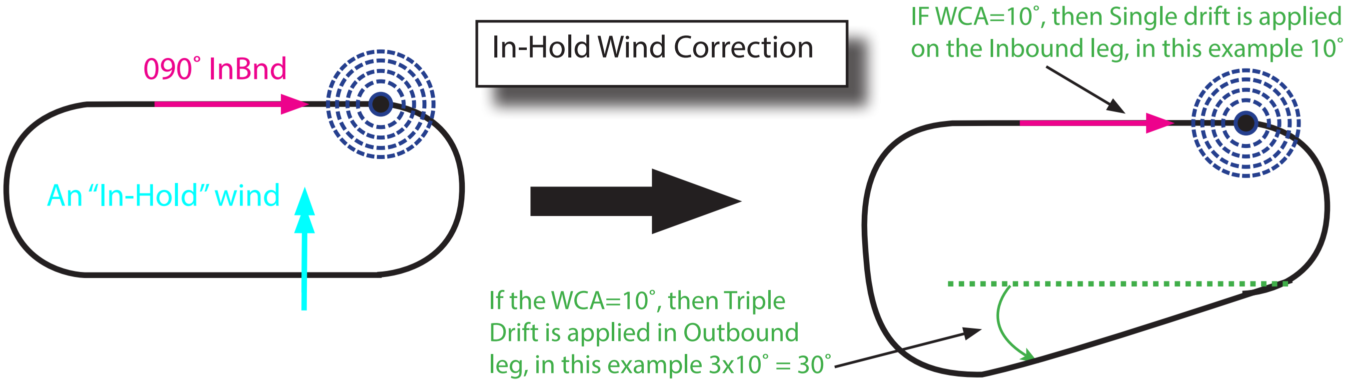
This means that the Hold must be flown as shown by the diagram on the right and the OutBound leg is flown on a Heading, not at 270˚, but at 240˚.

Remember "OH"on the Pilots PLOG? This is how you calculate it and record it in anticipation of arriving at the Hold and flying it correctly with compensation for the wind. eg OH:*240*˚

If the wind was stronger, or the aircraft slower and the Single-Drift for 270˚was 12˚, then the Outbound correction, would be

3x 12˚ = 36˚, so the leg in this example would be flown on a Heading of 234˚

It is therefore important that the airspeed of the aircraft is kept stable and constant, as t is this airspeed you will be using to calculate your WCA.



Out-Hold Wind Correction

When the wind is blowing such that an aircraft would be blown "out" of the hold when flying the Outbound leg, this is known as an "Out-Hold" wind. As we have seen, we can compensate for this wind by applying triple-drift to the outbound leg to compensate for the Outbound leg and two turns.

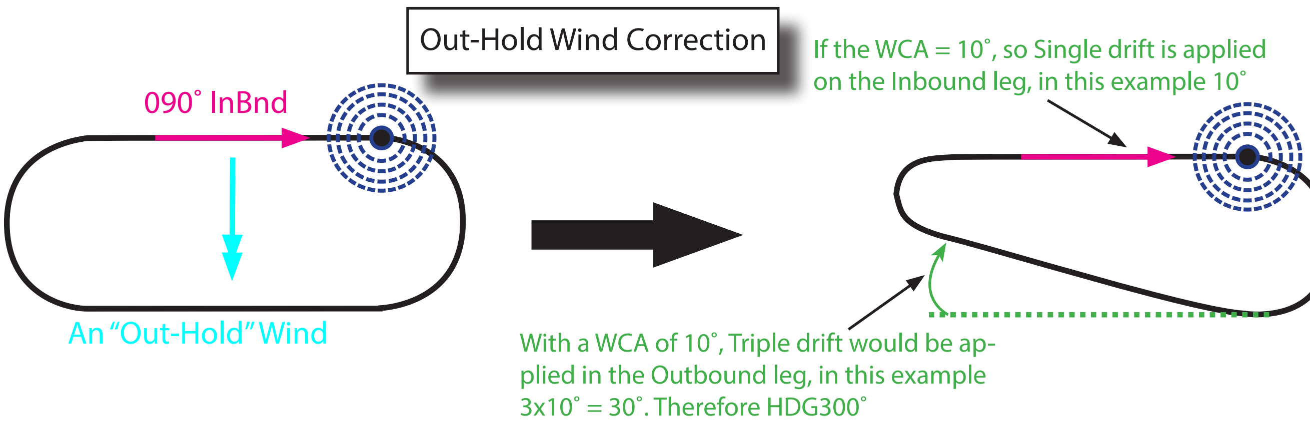
The same calculations are used, exactly as previously, except that the WCA is applied in the opposite direction.

If we use the previous example and take a Single-Drift WCA of 10˚ but this time from the North to the South (in the diagram below), then the Outbound leg would have be flown 3x 10˚ = 30º to compensate for the wind from the north.

So instead of flying 270˚Outbound, flying it correctly with compensation for the wind, the Pilot would instead have to steer, 300˚ to compensate for the Out-Hold wind during the Outbound leg and two turns

The Pilots PLOG would have be updated thus: eg OH:300˚

Similarly, if the wind was weaker, or the aircraft faster and the Single-Drift for 270˚was 6˚, then the Outbound correction, would be: 3 x 6˚ = 18˚, so the leg in this example would be flown on a Heading of 288˚



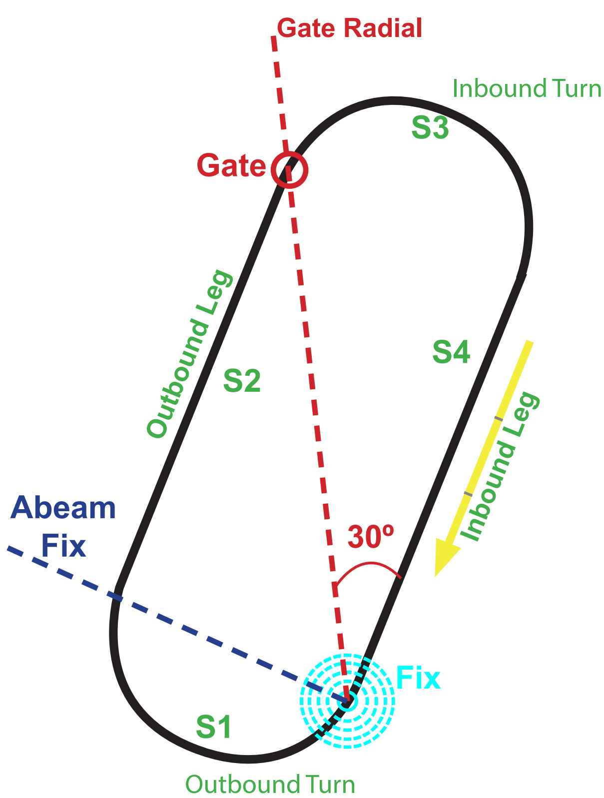
Managing the Hold: Abeam Fix and The Gate

The Gate and Abeam Fix are two places that allow for the pilot to make adjustments to their position and /or timings when flying a Hold.

Although pilot error often accounts for deviation from the ideal flightpath, more often it is variations in wind direction and strength at various levels that cause such deviations. The Abeam Fix and the Gate can be used to assist the pilot in assessing their progress.

The Abeam Fix, marks the start of the Outbound leg and is a radial 90˚ from the Inbound Track. In the case of a right-hand hold, it is +90˚ and for a left-hand hold it is -90˚.

Therefore for a right-hand Hold of Inbound track 202˚, the Abeam Fix is the 292˚ radial. That is the QDR292.
For a left-hand hold of Inbound track 202˚, the Abeam fix is the 112˚ radial, or QDR112.

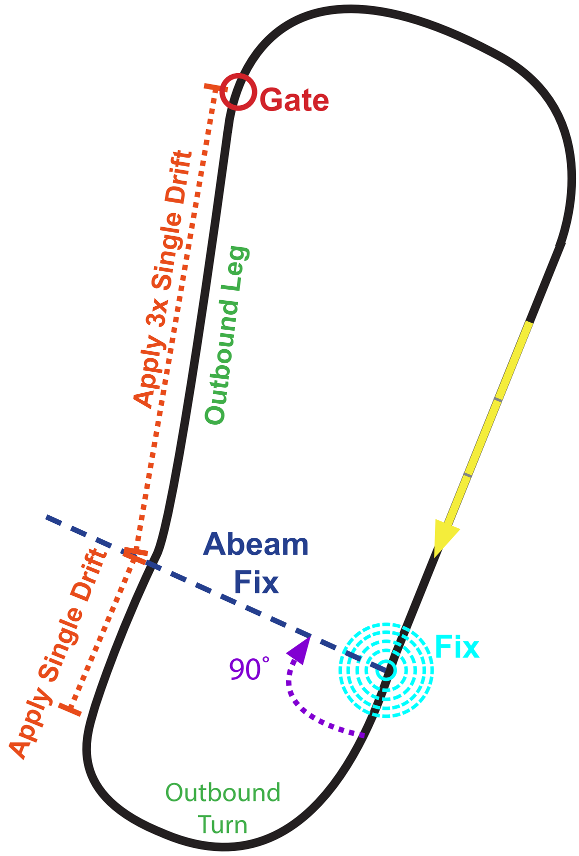


The Abeam Fix is used by the pilot to start the Outbound leg and by implication, the timing for the Outbound leg and also the start of any wind correction.

If the Pilot comes around the Outbound Turn, and finds themselves on the Outbound leg before reaching the Abeam Fix, then they should fly Single-drift until the Abeam Fix (shown right with orange line).

Once they have passed the Abeam Fix, they should then apply the calculated Triple Drift for the rest of the Outbound leg until they reach the Gate and turn to the Inbound Track.

By waiting for the Abeam Fix before apply the correction, this prevents over-compensation.



Hold Data
It:350 / R
Ot:170
Gt:140
Ab:040
Oh:155
Ot:68

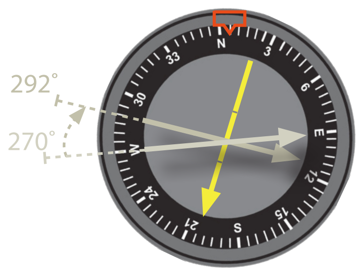
The second use of the Abeam Fix is for timing. Earlier we have seen that you may have to compensate in the Outbound leg for a Headwind or Tailwind.

If you look at the example Hold Data table on the left created by the pilot in-flight, we see they have calculated a triple drift of 15˚ (170˚->155˚) and an Outbound Timing of 68 seconds.

The point at which we start flying these two compensations is at the Abeam Fix, so for this Hold, before reaching the Abeam Fix, the pilots flies WCA 5˚=165˚ and on reaching the Abeam Fix the Pilot will turn onto 155˚ and restart their stopwatch to fly for 68 seconds.

How to Detect the Abeam Fix

There are two methods for determining when you are passing/have passed the Abeam Fix. RMI, RBI and HSI/OBI.



In the case of the RMI, you can use the Tail of the Needle as this is giving the QDR reading from the Beacon.

Consider the diagram on the top right. The Pilot has used the CDI to “bug” the Inbound track of this Hold of 202˚. They have selected a Heading 005˚ for Single-Drift, and the RMI/RBI Needle starts roughly west (light-grey needle), but as they are flying north, they are “pulling the tail” of the RMI Needle north.

As the aircraft flies north the Tail of the RMI Needle reaches 292˚, (dark grey needle) and they have reached the Abeam Fix for this particular Hold.

Alternatively if the Fix is a VOR Beacon, then the To/From flag will switch from TO to FROM at the 90˚ position, the Abeam Fix

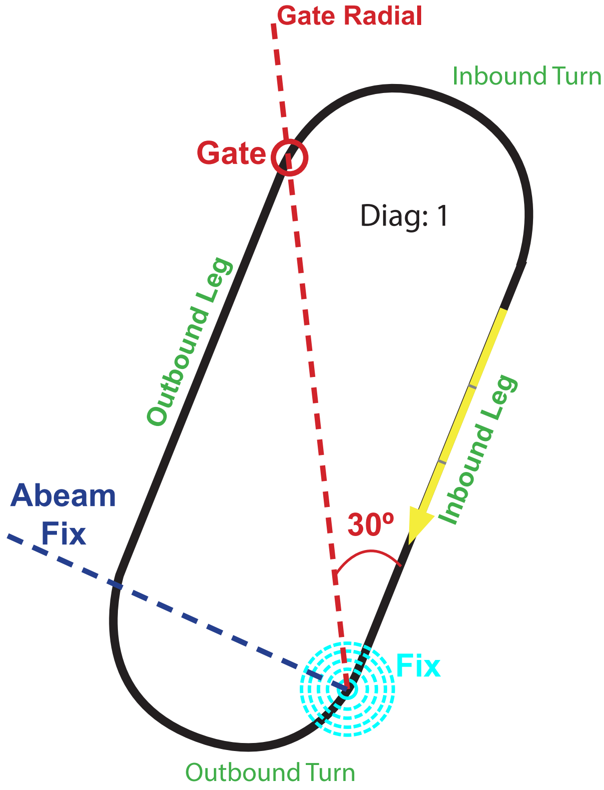
The Gate

The Gate is ideally the position of the intersection of a radial 150˚ clockwise on a Right-hand Hold (or anti-clockwise on a left-hand) with the Outbound leg.

It is more commonly described and illustrated as being 30˚ from the Outbound Hold. Left of the Outbound leg on a right-hand Hold and vice versa on a Left hand hold.

The Gate is the point at which the Inbound Turn is commenced, but as hinted above is only "ideally" at 30˚.

This is because the Gate can be moved when a cross-wind correction is made, and in doing so can be used to correct for inaccuracies when flying the Hold.



In-Hold Wind: Gate Correction

The Hold in Diag.1 shows a zero-wind idealised diagram of a Hold which you will have no doubt seen before.

However the if there is an In-Hold wind, then this will force the pilot to make an correction of triple-drift as illustrated in Diag 2.

Due to the Triple-Drift correction in the Outbound Leg, if we are to use the Gate as point at which we initiate the Inbound Turn we need to "move the Gate back".

That is we need to move the Gate close to the Abeam Fix. But by how much, well as before, short of getting out a calculator and our Cosine tables, we make an approximation.

The approximation is equal to the value of Single-Drift WAC.

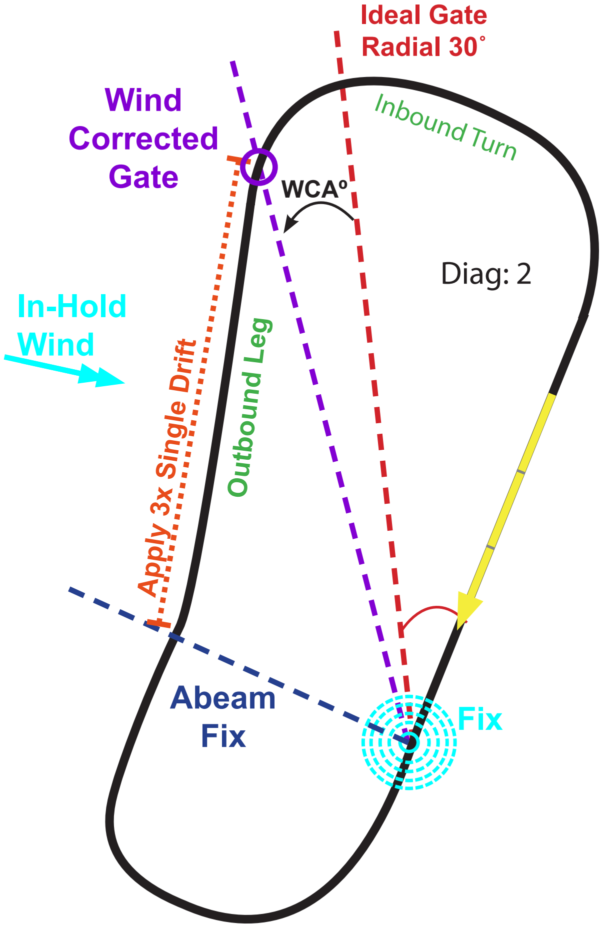
So for example if the Inbound Track of a Hold is 202˚, then the Outbound track is 022˚. 022-30˚ means a default Gate of 352˚. The picture in Diag:2 illustrates this.

If the Single Drift WCA is 10˚, then for an In-Hold wind we move the Gate back by 10˚, so 352-10 = 342˚

This is now our Wind-Corrected Gate and it is now at the Wind-Corrected Gate that we start the Inbound Turn.

If we have had to make a Wind-corrected timing because of a Head/Tailwind, then in theory we should arrive at the Wind-Corrected Gate at the same time as out Wind Corrected Timing.

Having gone to this effort, if however you arrive at the Wind-Corrected Gate early or late you can predict and adjust your flight to account for the impending error.



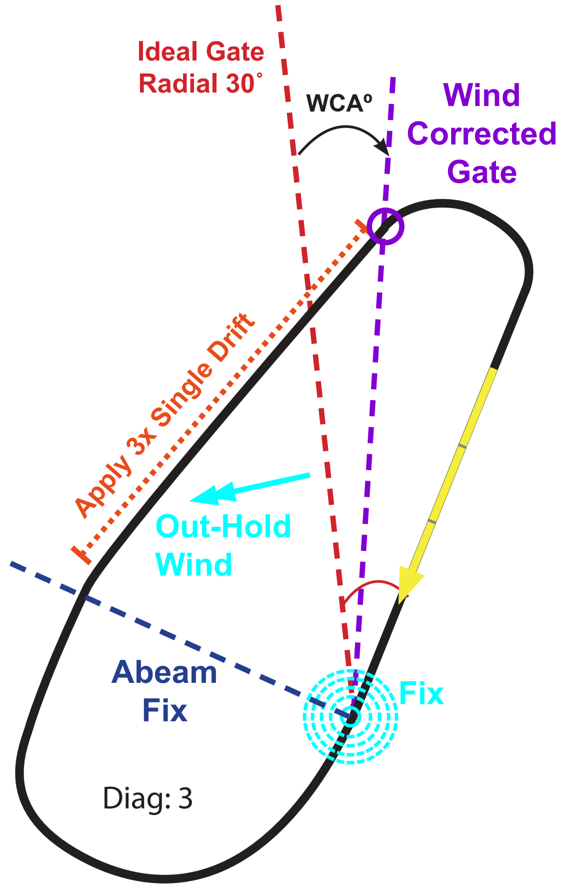
Out Hold Wind: Gate Correction

In the case of an Out-Hold wind, as the Outbound Triple-Drift is applied in the opposite direction toward the centre of the Hold, we need to move the Wind-Corrected Gate "forward", that is away from the Abeam Fix.

Using the same example numbers as in Diag 2, the Idealised Gate should be 352˚, but if the WCA Single-Drift is 10˚, then we move the Gate to 352+10= 002˚

This is now our Wind-Corrected Gate and again at the Wind-Corrected Gate that we start the Inbound Turn. We should arrive at the Wind-Corrected Gate at the same time as out Wind Corrected Timing.

Having gone to this effort, if however you arrive at the Wind-Corrected Gate early or late you can predict and adjust your flight to account error.



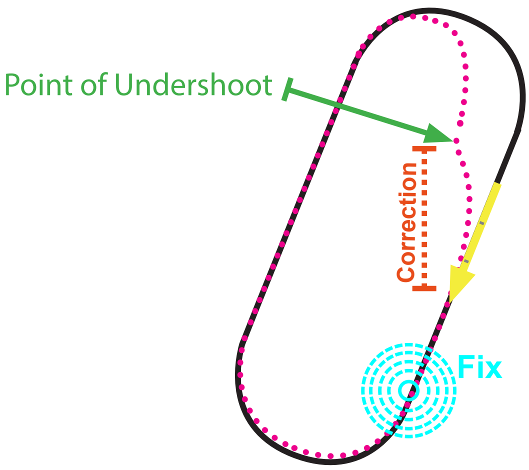
Error Corrections in the Hold

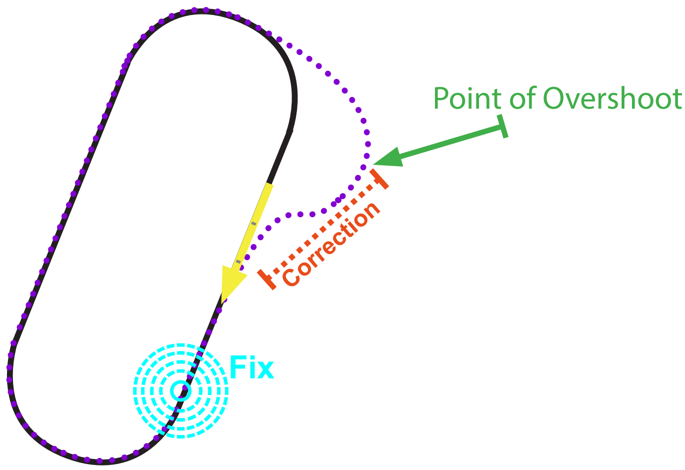
To undershoot or overshoot, this is the question

All of the equations, estimates and approximations there to make your mental arithmetic easy in the air, are all just that: "Approximations".
Your instructor, ATC and even your examiner cannot and will not, expect perfection as the wind and weather will do what it likes and you can only compensate for these changes as they arise.

What you <u>can</u> do, and <u>will</u> be expected to do is monitor your progress and make reasonable efforts to mitigate these errors and subsequently adjust your approximations in the face of new information. Failure to monitor and update, will be seen as failure of the lesson or worse your IR Exam.

Let us start with the Overshoot and the Undershoot and what they look like. Below on the left is an Undershoot, on the right an Overshoot. The names refer to the point of rolling out on the Inbound Heading, but not having achieved the Inbound QDM. In order to track correctly Inbound to the Fix, these errors must be corrected.





Wind Corrected Gate: The Early Warning System

> *Time before Gate, Undershoot, turn on time.*
> *Gate before Time, Overshoot, turn to Gate*

Learn the above "by heart" and you will save yourself a whole world of pain.

Gate Before Time, Turn to Gate

Correcting the Overshoot

In Fig:1, The pilot has started their Stopwatch on reaching the Abeam Fix, however they either have a stronger In-Hold Wind, or their Triple-Drift calculation was too much.

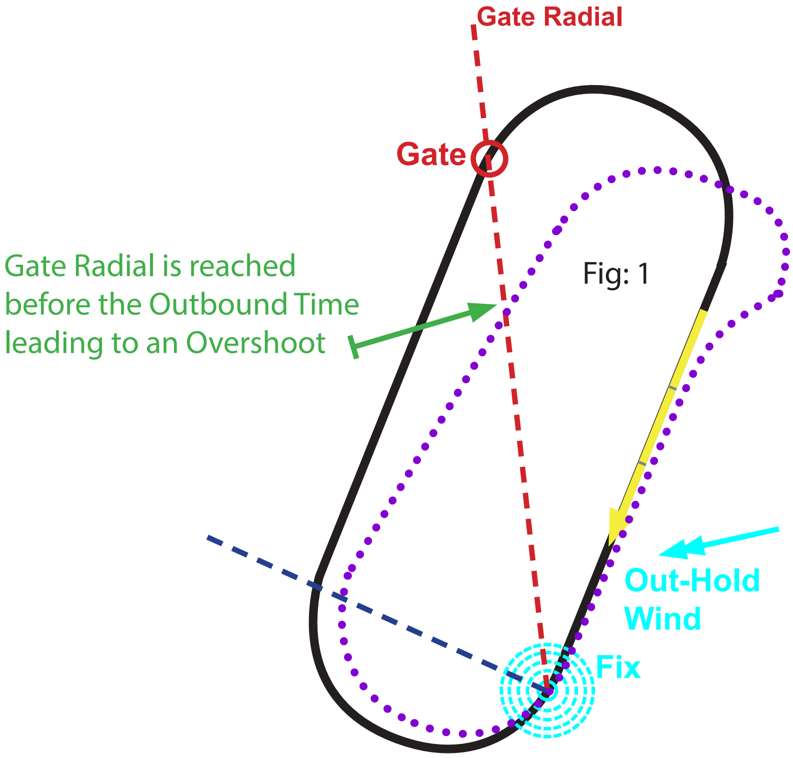
Either way, the Wind corrected Gate radial is reached before the Wind-Corrected time for the Outbound leg has been reached.

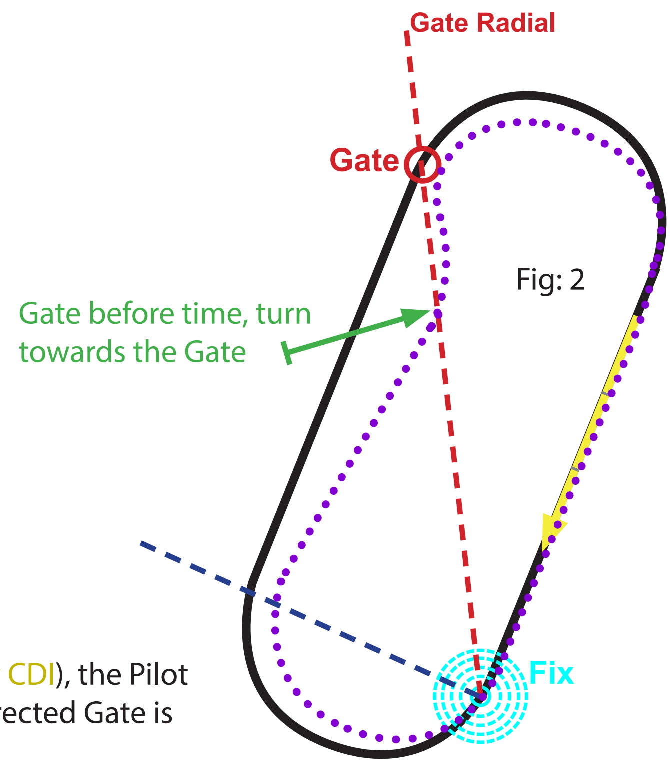
This will lead to an Overshoot.

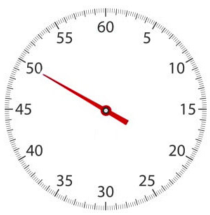
The Pilot can at this stage make a correction for the Overshoot.

They are unlike to completely eliminate it, but they can reduce it.

The solution; turn towards the Gate radial and fly along it until the Wind-Corrected time is completed. As can be seen by the Diag:2 this correction will reduce the







In this example the Inbound Track is 202˚ (yellow CDI), the Pilot is flying a Triple-Drift HDG of 030˚. The Wind corrected Gate is 350˚ & Wind Corrected time is 68s.

The Timer says 50 seconds, but the RMI/RBI tail of the orange needle already shows a QDR of 350˚. The Gate has been reached befire time. So turn towards the Gate until 68s.

Time Before Gate, Turn on Time

Correcting the Undershoot

In Fig:3, The pilot has started their Stopwatch on reaching the Abeam Fix, however they either have a weaker In-Hold Wind, or their Triple-Drift calculation was too great.

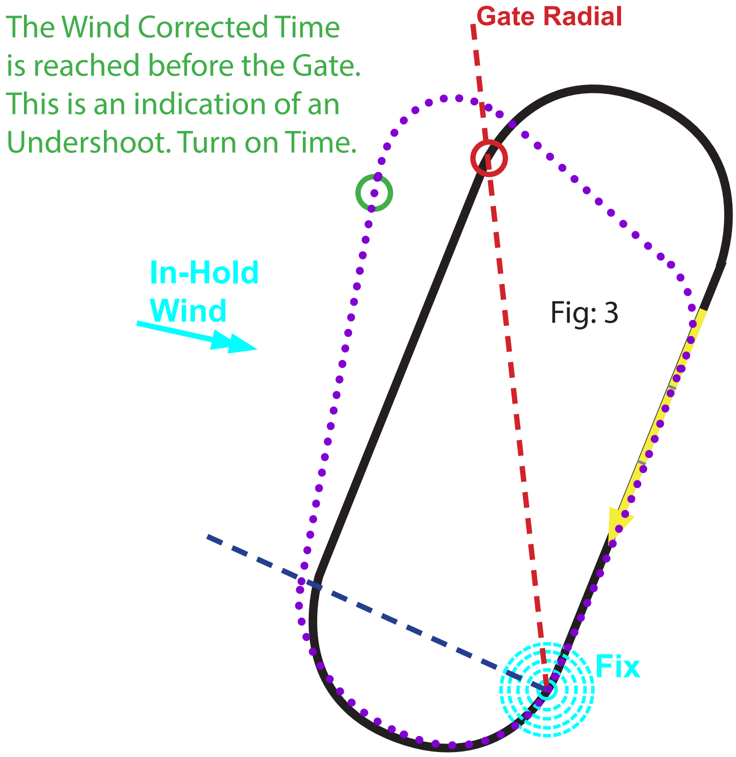
Either way, the Wind corrected Time is reached before the Wind-Corrected Gate has been reached.

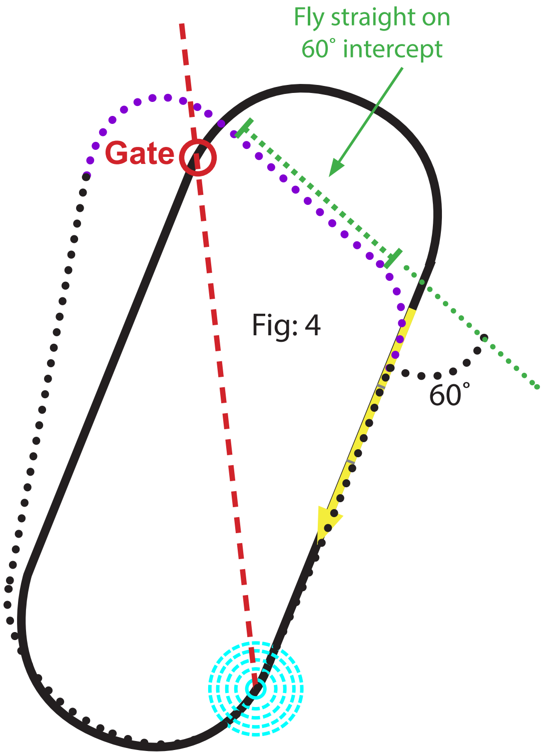
This will lead to an Undershoot.
(“*Time before Gate*”)

The Pilot can at this stage make a correction for the Undershoot.

They should turn towards the Inbound Track as normal in a Inbound Turn, but should roll out when 60˚ from the inbound Track QDM. Shown in Fig: 4 as the green line.

The pilot continues to fly straight to intercept the Inbound Track QDM to the Fix.

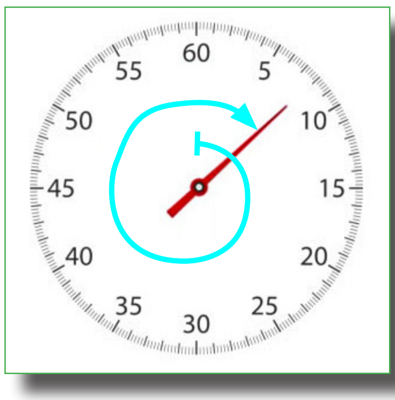




In this example the Inbound Track is 202˚ (yellow CDI), the Pilot is flying a Triple-Drift HDG of 340˚. The Wind corrected Gate is 325˚ & Wind Corrected time is 68s.

The Timer says 68 seconds, but the RMI/RBI tail of the orange needle only shows a QDR of 300˚ (not 345˚). The Time has been reached before the Gate. So turn towards the Inbound Track, but roll out when 60˚ from the Inbound QDM.

Continue to fly straight with an approximate 60˚ intercept angle of ~160˚ to then intercept the Inbound Track QDM of 202˚ to the Fix.



Intercepting the Inbound Track

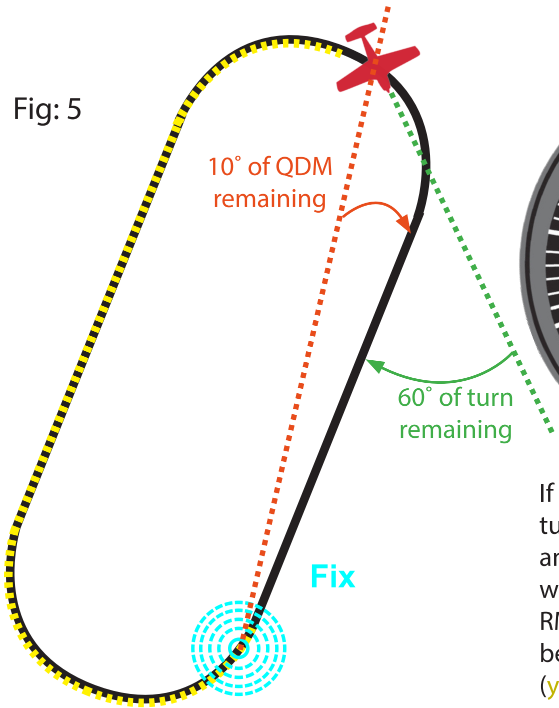
Whilst in the Inbound Turn, it is possible to predict if there will be an Undershoot or Overshoot.
This is another opportunity to judge the accuracy of the Hold, and that is at the 60˚-of-remaining-turn, point of the Inbound Turn.

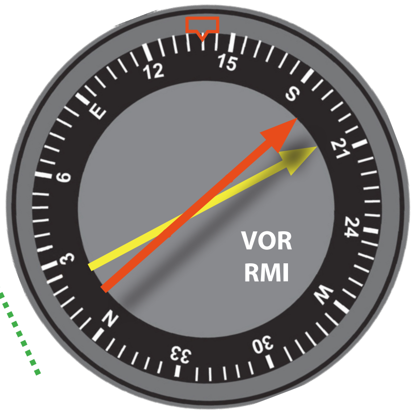
When the aircraft has a Heading that is approximately 60˚ of turn remaining (green line below) onto the Inbound QDM, the aircraft **should** have 10˚ of QDM remaining to intercept.

In Fig:5 below, the aircraft is turning in the Inbound Turn towards the Inbound Track of 202˚ to the Fix.
The Aircraft has reached the 60º of turn remaining position, so therefore is on a heading of
202˚ - 60˚= ~140˚ (*note the HDG Bug position below*).

This is also 10˚ short of the QDM, so the Head of the Needle on a VOR-RMI instrument on the left (without Dip), should read 202 - 10 = ~190˚, but the NDB/ADF needle on the right instrument will suffer 10˚ of Dip meaning that QDM and the Needle position are the same. This is the ideal position as illustrated in Fig. 5.

Fig: 5





If the aircraft reaches 60˚ of turn remaining (here 140˚) and if the Fix is a VOR or GNSS waypoint, then the Head of the RMI indicator (orange) should be 10˚ before the desired QDM. (yellow bugged needle)

If the Fix is an NDB then for the same position, the head of the ADF indicator (green)will be equal to the desired QDM as the -10˚ of QDM will be cancelled out by the +10˚ of NDB Dip, so long as a rate-one turn is maintained.

Predicting an Undershoot

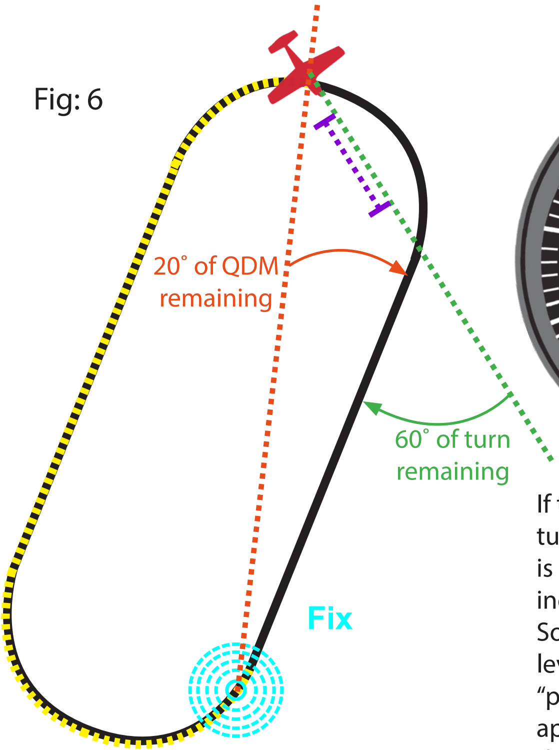
If the Aircraft gets to the 60˚-of-turn-remaining position and has more than 10˚of QDM to intercept, then this indicates an Undershoot (see Fig:6), here ii is easier to visualise the effect of an undershoot and how to interpret the position with the RBI/RMI.

The solution is to roll the wings level, on the 60˚ intercept and *push the head* of the RBI/RMI needle towards the desired QDM. When the needle reads 10˚ of QDM re-commence the turn to intercept the Inbound Track.

Note on NDB's. If you are carrying out a reasonably accurate rate-one turn, then the ADF needle will be suffering from NDB-dip of aprox 10˚, but as soon as you roll wings-level the Dip will disappear.
What this means in reality is that if <say> at the 60˚ turn position you were actually 20˚short of QDM, then the ADF needle will show 10˚ QDM error in the turn (not 20˚), but once wings-level, the Dip will disappear and the needle will indicate 20˚ error. Now there is no Dip, the ADF can be trusted.

You should now fly accurately until the ADF reads QDM less 10˚ and then re-commence your Inbound Turn. The Dip will re-appear and the ADF needle should read exactly QDM (-10+10=0), but once the aircraft has intercepted the QDM, the ADF will read QDM + 10˚ (in this example 212˚) just before you roll out. As soon as you roll out and once the wings are level, Dip disappears again, then the ADF will read the QDM, as desired.

Fig: 6



If the aircraft reaches 60˚ of turn (here 140˚) but the QDM is more than 10˚, then this is an indication of an **Undershoot**. Solution: Roll wings level, fly level (the purple track in Fig:6) "push the Head" until the QDM approaches 10˚ then turn onto the QDM

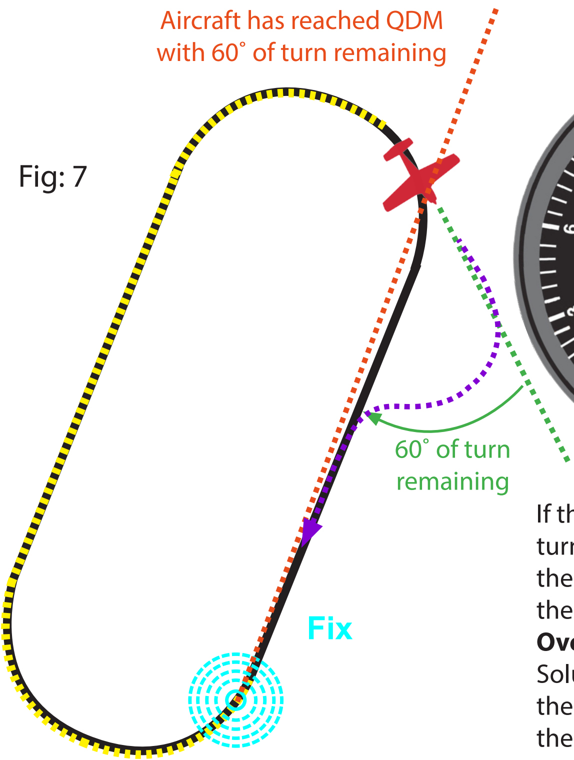
If the Fix is an NDB the head of the ADF indicator will read 10˚ below the desired QDM as the -20˚ of QDM will be cancelled out by +10˚ of NDB Dip. Roll wings level, but because the Dip now disappears wait until 10˚ below QDM before continuing the turn, at which point the needle Dip comes back and the needle will read 202˚

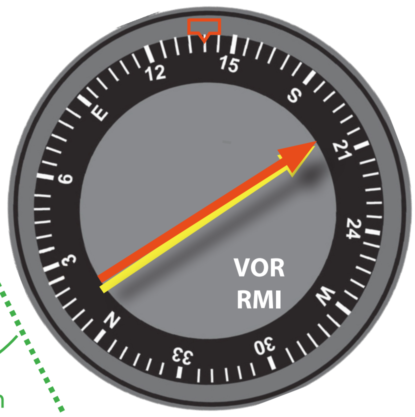
Predicting an Overshoot

In the case of an Overshoot, if when you reach 60˚of turn remaining and the QDM is less than 10˚, then you have an overshoot scenario. The situation is illustrated below where the Heading is ~140˚, but the QDM is already 202˚, the desired Inbound Track. Here the aircraft has reached 140˚ (60˚ less than the Inbound track of 202˚), but the RMI/RBI is indicating that the Inbound QDM has been achieved.

This is an Overshoot situation. The solution is to continue turning until you have achieved a heading of QDM +30˚, which in this example would mean a heading of ~230˚. This will allow you to re-intercept the 202˚ QDM of the Inbound track.

Fig: 7





If the aircraft reaches 60˚ of turn (here 140˚) but the QDM is the same as the Inbound Track, then this is an indication of an **Overshoot**.
Solution: Continue truing past the Inbound track by ~30˚ and then re-intercept the Inbound Track

If the Fix is an NDB the head of the ADF indicator will be 10˚ beyond the desired Inbound Track.
Continue to turn past the QDM by aprox 40˚ of the indicated QDM. In the above example aprox 240˚.
Once within 10˚ QDM (~220) turn back towards the desired Inbound Track and you should intercept the QDM of 202˚.

Undershoot, Overshoot Management

Managing the Hold is a matter of carrying out the monitoring at the correct time. If you miss the 60˚ Turn -remaining point, its not the end of the world, but you just made your job a whole lot harder.

In addition to a the ideal position at the 60˚turn point, you can also check at the 30˚-turn-remaining point. As with the 60˚point, at the 30˚ point you should be ~5˚ from the QDM, so another chance to check your progress and accuracy.

Below is a table which summarises the Turn position fixes and the respective QDM's.

Inbound Turn Position Fix Table

Position Fix	VOR / GNSS Fix	NDB / ADF
60˚ of turn remaining in turn	10˚ QDM remaining indicated	0˚ QDM
60˚ of turn remaining wings level	10˚ QDM remaining indicated	10˚ QDM remaining indicated
30˚ of turn remaining in turn	5˚ QDM remaining indicated	5˚ **over** QDM indicated
30˚ of turn remaining wings level	5˚ QDM remaining indicated	5˚ QDM remaining indicated
No turn remaining, in turn	0˚ QDM remaining indicated	10˚ **over** QDM indicated
No turn remaining, wings level	0˚ QDM remaining indicated	0˚ QDM remaining indicated

You need to learn the above table. It is not as difficult as it first may seem.
There are only 3 Fix positions to learn for VOR/GNSS, and that when the wings level they are identical to the ADF.

So of 12 items, this reduces to 3, and for the Fixes for the ADF when turning, that's just a case of "add 10˚", so in effect just 4 items to learn.

Dealing with an Undershoot is fairly straightforward, as you only need to roll the wings level, push-the-head and intercept the Inbound Track.

The Overshoot is a bit more tricky, and you should select an intercept no more than 30˚ beyond the QDM as anything greater than 30˚ will likely lead to you over-shooting again, and ending up with an Undershoot.

NDB Dip Management

As stated earlier, the NDB Dip is a nuisance that cannot be eliminated, just managed, it is recommended that a thorough understanding of the limitations and errors of the ADF and associated Needle-Dip are understood before attempting a Hold based upon an NDB

NDB Dip is caused by unavoidable errors inthe sense antenna when banked. These are consistent and reproducble. For most metal light-aircraft the Dip is aprox 10˚ of Dip for 18˚-20˚ angle of Bank. It is therefore important that you maintain a constant speed to ensure that your Bank-angle remains consistant to maintain your Rate-One turns.

Angle of Bank (Rate One, 3˚/Sec) is given by: (TAS÷10) + 7

You should therefore ensure good speed control and only fly Rate-One turns. If you reduce you r angle of bank to <say> 10˚, then the Dip becomes unpredictable and the position Fix table above, cannot be used.

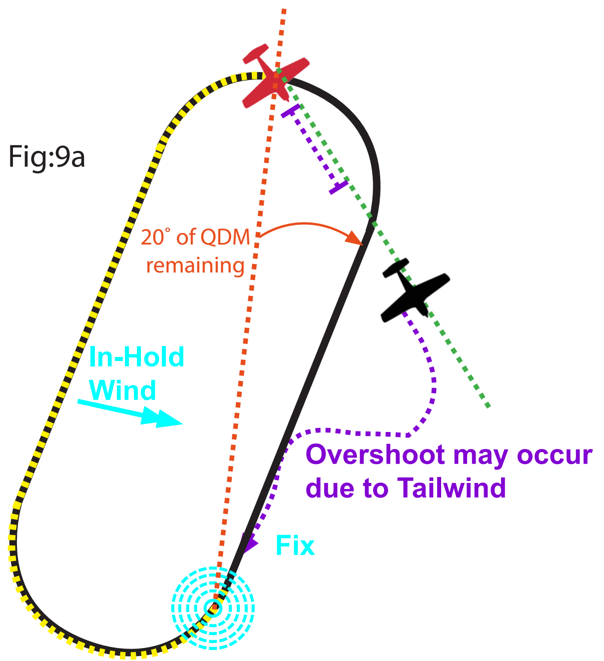
This means you will not be able to accurately judge your progress and accuracy through the Hold

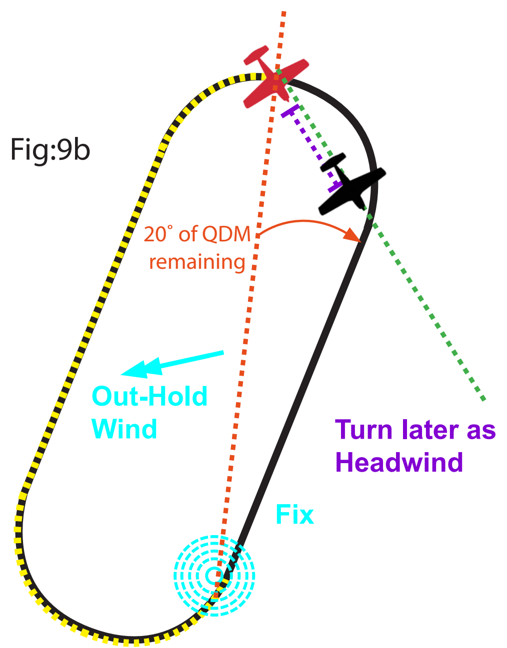
Wind-Induced Undershoot and Overshoot

The previous Table states that in ideal conditions at 60˚ you should have 10˚ QDM., however when rolling out onto the Inbound Track/ QDM to the Fix be carefull if there is a srtong In-Hold ot Out-Hold wind in play as this may upset your intercept.

In Fig:9a, it can be seen that potentially an Undershoot could be turned into an Overshoot due to the fact there is a strong tailwind that is "pushing" the aircraft, which could lead to the aircraft overshooting the QDM (black aircraft position below)
Solution, turn earlier, or expect and plan for an Overshoot.

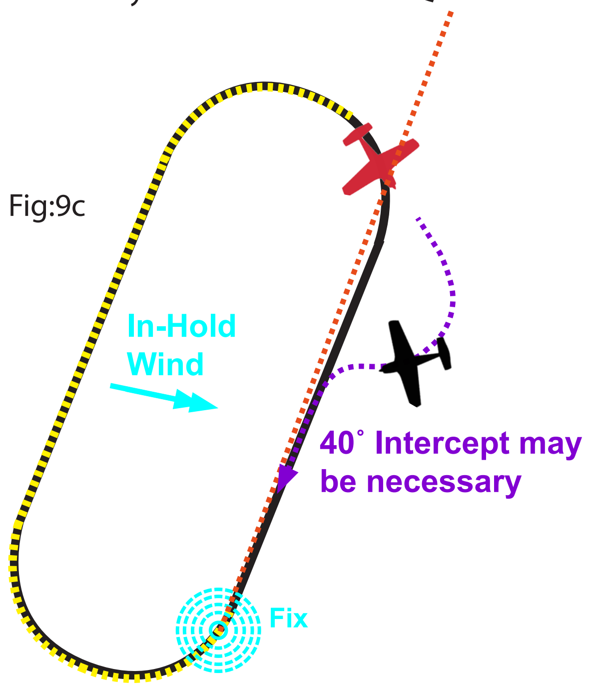
If there is a strong headwind, that is an Out-Hold wind (Fig:9b) turn slightly later, perhaps at the 5˚ QDM not the 10˚ QDM as is usual.

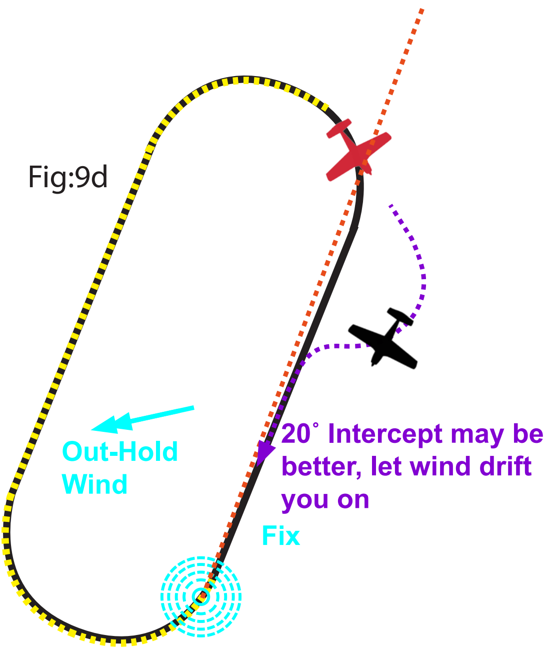




If you have Over-shot and you have a strong In-Hold wind (Fig:9c), then be prepared to use a 40˚ intercept (not 30˚ as previously recommended) or wait longer to re-intercept the Inbound Track.

However, if you have a Tailwind/Out-Hold wind, then you may need a lesser Intercept angle (~20˚) and let the wind drift you onto the desired QDM. For once the wind is your friend! (Fig:9d)





Stephen's Little Cheats and Helpers

Having sat next to enough students over the past years and having flown my own holds eneough, I have developed a number of "cheats" or helpers that will assist in helping you to fly an accurate Hold.

None of them are "textbook", but real-world flying never is. The wind is never what was predicted. ATC will have you Holding at an altitude which you hadn't planned for, or even a place you were not expecting !!

Learn from me and they will help,

Helper #1: Cone of Confusion

Within aprox 1nm of a Beacon the Cone of Confusion causes misalignment for the RBI/RMI needle and the actual QDM.

Solution, once established Inbound to the Fox on the correct QDM, get your WCA single-drift correction "Bugged-up", that is set on your Heading Bug. Then within 1NM just fly the Bug and trust it, not the needle. This will avoid you getting off course as you "chase the needle.

Helper #2: Extending over the Fix: Abeam Fix.

This one is easy, when overflying a Beacon you will be inside the "Cone of Confusion", so don't trust the needle.

So simply continue on your Bugged heading until you have had "full beacon passage", this is when the RMI/RBI needle becomes stable and is fully pointing behind you.

Slowly and laconically reset the Timer, turn, talk and twist. All the time flying for an extra few seconds into wind ("Extend Here" in Fig:10) and away from the beacon.

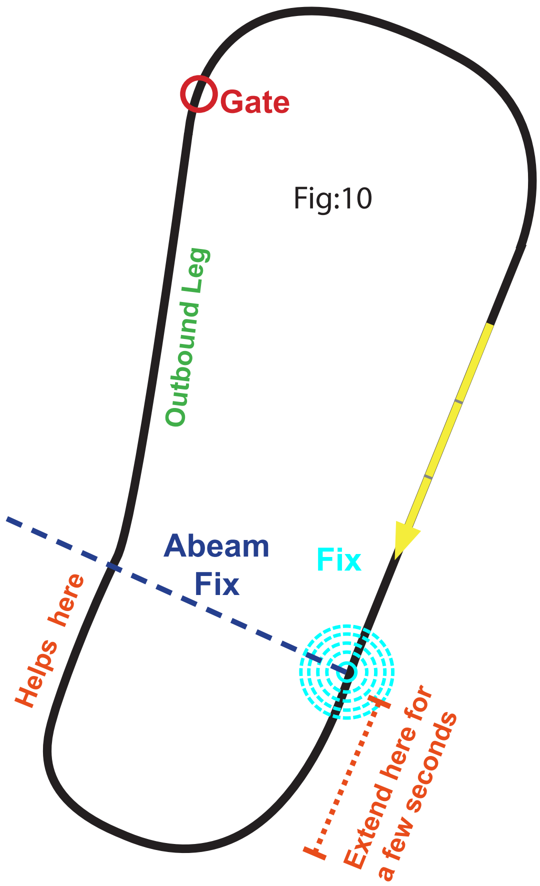
In just that extra 10s of complete Beacon passage you will have flown aprox' another 400m before you start your Outbound Turn.

Why is this important? Because it almost guarantees that you will get the wings level before reaching the Abeam Fix when on the Outbound Leg by about the same 400m or 10 seconds ("Helps Here")

It is hard enough getting an Abeam Fix with a VOR/GNSS which does not suffer Turn-Dip.

Trying to get an Abeam Fix with an ADF whilst still turning and with 10˚ Dip is hard enough for advanced Pilots let alone Students. Make life easy on yourself.

Get wings level for a few seconds before the Abeam Fix is due

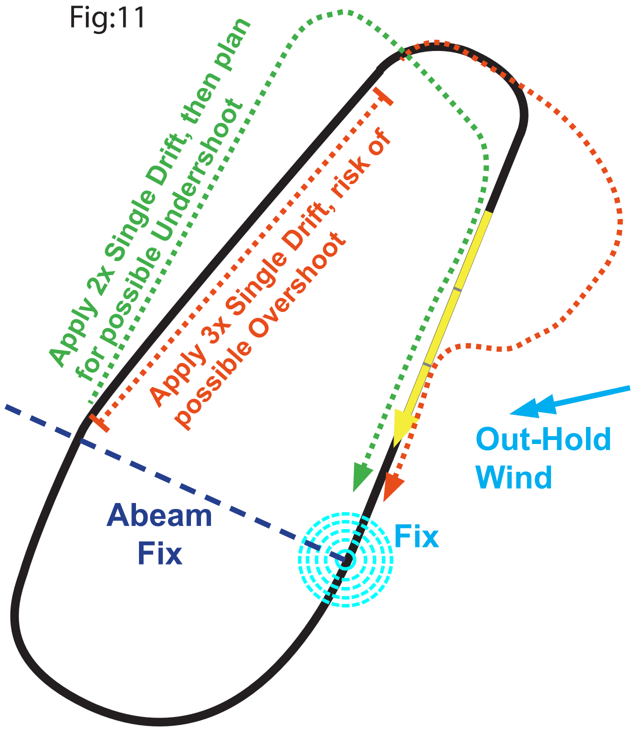


Helper #3: Double-Drift with Out-Hold Wind

The Textbook states that you should always apply 3x or triple drift in the Outbound Leg. When you have an Out-Hold Wind, there is a very real risk of over-calculating the Single-Drift WCA and therefore flying too much correction with a consequential Overshoot. (Orange Track in Fig:11 below)

Helper #3 suggests that when you have an Out-Hold wind that you limit the Outbound correction to double-drift (2x Single-Drift) and then expect a small Undershoot. (green track)

Fig:11



An Undershoot is very easy to fix as you just need to roll the wings level for a short time.

Undershoots, once you have practised them are much easier to manage and control than Overshoot.

Also Undershoots are safer than Overshoots as you remain on the "inside" of the Hold where the obstacle clearance separation heights are more favourable.

Although Fig:11 is exaggerated, it illustrates the point.

How to Plan, Approach and Fly a Hold

*The six-P's: "Proper planning prevents p***-poor performance" HM-RN*

Proper planning indeed. It is not possible to plan for every eventuality on the ground as circumstances may and will change and you as an IR candidate must have the capacity to be able to re-plan and cope with changes mid-flight.

Therefore it is pointless planning every last detail prior to flight, and this is especially true of the Hold.

During an IR Skills test (and in reality) there is time to plan your Hold, Single-Drift and WCA, Hold Entry, Timing corrections, Gate correction, Outbound heading corrections and build some situational awareness of drift when turning Inbound to the Fix QDM.

So when to do it? Preferably once en-route and your terminal beacon is known. This will be as a result of listening to the ATIS at the destination Airport as soon as is practical.
eg. at Sevilla, will you go to TENDU or ROTEX (based on runways 09 or 27 respectively)?
What is their respective holds. Is it en-rout or Beacon based??

Given that the ATIS from 3000' has a propagation range of 60miles, you have at least 10 minutes to plan your hold. This is plenty of time if you are organised.

Step 1: Get a Pilots PLOG, on a Kneeboard, and have some kind of Hold Planner space set aside for it.

Below is one that I suggest you consider. The Hold Data in black text (IT->Ab) are all just taken off the plate and will help with your calculations.

The calculated fields are the ones marked in red.

In this example the pilot has calculated a single drift WCA of 7˚ and westerly for their own situational awareness, from the wind strength and direction.

Outbound Heading is calculated off of the SD as being either triple or double-drift (see Helper #3).

Outbound Timing is calculated as preciously shown, and this indicates a slight tailwind of 4 Kts.

Finally the corrected Gate is calculated as being the Gate less single drift.

It all looks complicated at first, but it isn't really and with a little practice can be done quite quickly.

Hold Example #1

It:202 - R
Ot:022
Gt:352
Ab:292
SD:7 (w)
Oh:001
Ot:56
Cg:345

IT : The Inbound Track and Hold Direction (Right Hand Hold, Left Hand Hold) namely RHH and LHH *(taken from the plate)*
OT: The Outbound Track (180˚)
Gt: The Gate (-30 from OT (R), or +30 (L)
Ab: Abeam Fix: IT+90 (RH), -90 (LH)
SD: Single Drift WCA based on W/V & IT
OH: OT track corrected for wind (3x,2x SD)
OT: Outbound Time based on Head/Tailwind
Cg: Corrected Gate (Gt-SD for In-Hold Wind RHH), (Gt + SD for OutHold Wind RHH), (Gt+SD for In-Hold Wind LHH), (Gt - SD for OutHold Wind LHH)

Step 2: Time Turn Talk Twist

Every time, without fail, you go over or transit the beacon, you will **Time, Turn, Talk and Twist.**

TIME: *Reset the timer.* If you forget to reset the timer at the Abeam fix, all is not lost, you can just deduct 60s for the Outbound turn (it's rate-one remember?) from your Outbound corrected timing. If you forget to turn on at the Gate, then when you realise your mistake, looking at your Timer will tell you how far you have gone (in seconds) from the Beacon so you can make an estimate of how long you need to fly Inbound to the Beacon.

This is a must, not an option. Failure to reset the Timer when over the beacon is an invitation to the Examiner to "partial you"

TURN: *Turn onto the Outbound Time.* That is not to say you can't wait for full beacon passage to occur before starting the turn. Helper #2. But be careful not to exaggerate.
5 seconds is usually ample, unless you have a strong Inbound Headwind, in which case expect that you wont get an Abeam Fix.

No Abeam Fix, no problem. If you have gone the Abeam Fix whilst still in the Outbound turn due to the wind and before the wings became level, just leave the timer running when the wings become level and monitor the Gate and the time less 60seconds from the Beacon.

TALK: *Tell ATC you are taking up the Hold*
If the first time over the Beacon for a Direct Entry, call ATC and say "*CALLSIGN taking up the hold at <beacon>, altitude <xxxx'>, QHN1xxx*"

If the entry was Parallel or Offset, it is the second time over the Beacon/Fix when you call ATC.

If ATC are very busy, then don't bother them and wait until next time. They can still see you on their radar, so don't worry too much about it.

But if you can then do call as it is a test requirement. If ATC are busy the Examiner has some latitude to ignore this, what he wont want to hear is you talking over communications between ATC and commercial traffic. Once over the Beacon and youve proudly told ATC where you are, shut up and fly the Hold.

The next time you need to speak to them is when you are ready for the Approach, or to acknowledge that they need to kick you up to a higher altitude to enable a commercial arrival to fly underneath you!

TWIST: *Twist your heading Bug onto your Outbound Heading* (single-drift wind corrected heading).
This way you know where you are goinf in the Outbound Turn!
If you end up coming wings level before the Abeam Fix, great just fly the Bug, then anticipate the 2x/3x Outbound Track correction.

Now try to remember Time,Turn Talk and Twist every time you go over the Beacon / Fix.

Step 3: Monitor and Correct
If you only get to fly one Hold, then you are both lucky and unlucky. Lucky that if you flew it well, you don't have to repeat the exercise and you have passed the Holds part of the IR Skills test. If you didn't fly it well, you won't get a chance to prove that you can correct your mistakes.
Alternatively if you are held by ATC in the Hold, it means that you have to keep flying it well, but if you really are a sky-god, this is time to impress the Examiner and send them to sleep for the rest of the test with your prowess!

Less facetiously, If you find yourself having to do multiple Holds, impress the Examiner by stating if an Overshoot or Undershoot has occurred, and then stating what you intent to do. Move change the Outbound Wind corrected heading by a few degrees. (usually no more than 5˚)

You should arrive back at the beacon after 4 minutes. If not then take the difference, divide by 2 and try the new timing on the Outbound Track.

Example: For a wind corrected OutBound Track timing of 54 seconds, if you arrive back at the Fix at 3mins 50seconds, that is 10 seconds too soon. So add half (5s) to the Outbound Timing, so 54+5= 59s and try again.

The Same goes for the Outbound wind-corrected heading. If you Undershot, make a change to the 2x or 3x drift correction and move the corrected Gate Heading next time around the Hold to reduce it (5˚ is a good start). Same with an Overshoot, make a change to the Outbound.

What you are trying to demonstrate here to the Examiner is not that you are perfect (no-one is), but rather that you have correctly identified an error and made a sensible estimate of what needs to be done to correct it.

Using the RBI

There are two instruments that an IF Pilot will use to track QDM/QDR's to a Beacon or Fix or to intercept radials, or relevant here, enter and maintain Holds.

These instruments are the Radio Magnetic Indicator ("RMI") and the Radio Bearing Indicator ("RBI"), it is important to understand the difference between and how to use them.

Typical RMI

Shown on the left is a typical RMI. This instrument has one other very powerful feature. The compass rose is slaved to a magnetic flux gate, which automatically rotates the compass rose to always be in alignment with the nose of the aircraft.

It has two needles which can be independently driven by either two VOR receivers, or more typically, one VOR receiver and one ADF receiver. The pilot can select which needle (green or yellow in this case) represents the QDM to 2x VOR's or 1x VOR beacon or an NDB Beacon. *(It is very unusual these days to have 2x ADF receivers fitted, but it is theoretically possible to have 2x ADF's configured, one on each needle)*

The head of the needle gives a direct readout of the QDM to the selected beacon. The Tail by deduction is the QDR or radial from the beacon.

In the illustration, this aircraft has a magnetic heading of ~193˚

The pilot does not have to rotate the compass rose to align it with the heading of the aircraft. As a result it is instantly intuitive as what the QDM is to a particular beacon as the QDM (or QDR) can be read directly off of the face of the instrument. This makes in considerably easier to use than the RBI.

The RBI is a much simpler instrument and typically consists of a single unit, only connected to the ADF receiver.

The Compass Rose, can be rotated, but only manually using a "HDG" knob. This means that if the Pilot aligns the Compass Rose with the aircraft's Heading, then a direct readout of QDM / QDR is possible.

If the aircraft turns, then the Compass Rose does not, and the pilot can no longer directly read QDM/QDR.

Worse, in turbulence, IMC conditions or when flying under stressful situations (such as a hold) it quickly becomes an unnecessary distraction to have to continuously manually realign the Compass Rose with Heading.

For this reason it is highly recommended to adopt the "North - Up" standard and use mental arithmetic to interpret the display on the RBI face.

In this case, the Pilot sets N (360˚) under the top lubber line at the top of the display and then uses the aircraft's heading from the magnetic compass or Direction Indicator to mentally calculate the QDM or QDR using the needle on the display.

This is possible, because although the Compass Rose does not rotate with the Heading of the Aircraft, the Needle correctly points in the direction of beacon "Relative" to the Heading of the aircraft. Hence its name.

In the diagram to the left, the Relative Bearing is 058˚ Relative.

Therefore if the aircraft was heading East (090˚ and not shown) the QDM to the beacon would be 90+58 = 148˚ and by deduction the QDR would be 328˚.

There are several challenges to using an RBI to monitor your progress around a Hold, so here are the issues and some solutions.

Needle Dip.

The RBI is a display of the ADF, which suffers from Antenna Dip, so therefore at a Rate-One turn the needle appears to "extra heavy" and "falls" by 10˚.

Needle Dip can be compensated by the pilot, but it requires three things.
1. You need to know you are turning, 2. you must maintain a Rate-One turn, and 3. you must maintain a constant speed.

Try not to roll the aircraft unnecessarily as it will make the needle unstable and almost impossible to use.

Abeam Fix
Ensuring that you achieve an Abeam fix is important for timing on the Outbound leg. Being able to fly (even if it is for only 3-4 seconds) wings level, gives the pilot time to adjust for wind drift.

In the case of the RBI this takes on even more importance as it allows the RBI needle to settle, without Dip, before reaching the Abeam Fix.

This means that if the Pilot successfully rolls wings-level before arriving at the Abeam Fix, then the RBI will indicate the Abeam transit with the needle being at the Easterly position, ie 090˚ Relative bearing for a Right-Hand Hold, or a Westerly position ie 270˚ Relative Bearing for a Left-Hand Hold.

***Solution*:** take a look again at Helper #2, to assist in arriving on the Outbound Leg wings-level

Gate QDR
You need to know if you have reached or failed to reach the Corrected Gate in order for your wind corrections to work and for prediction of Undershoot or Overshoot.

I suggest you modify your Hold Plog Planner, to include a Relative Bearing for the Tail of the needle at the Wind Corrected Gate. This is actually not as difficult as it may seem, as you deduct you Wind Corrected Heading from the Wind Corrected Gate QDR, "G_T". Look at Example #2

Hold Example #2

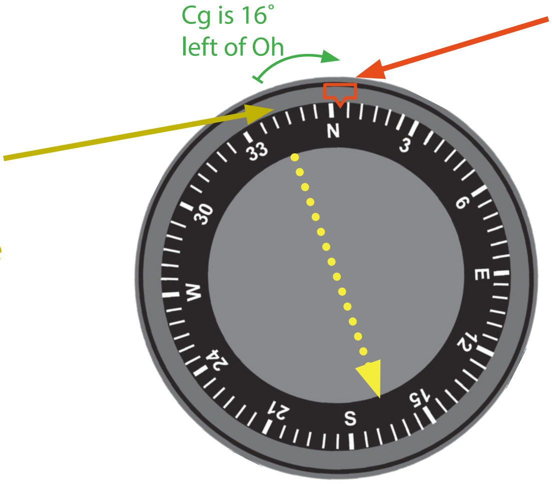
I_T:202 - R
O_T:022
Gt:352
Ab:292
SD:7 (w)
Oh:001
Ot:56
Cg:345

G_{RB}: 16 left

You will already have already worked out "G_T" and also your "O_H", so it is easy to calculate the Gate Relative Bearing ("G_{RB}")

001˚ -> 345˚ = 16˚ left of North
That is 344˚ to the left of North/360º Relative Bearing

When the tail of the RBI needle reaches 16˚left of North, or an indicated bearing (on the fixed Compass Rose) of 344˚, then this is the Corrected Gate bearing, and time to check the Timer.



Inbound Turn Position Fix

This is where you have to rely on your DI or Compass to check your 60˚ remaining turn position and the QDM. When using an RMI, this is relatively easy as the Compass Rose will rotate and if you have bugged your CDI, then the 60-turn-remaining Check point can be read off from the top lubber line of the RMI/HSI.

Hold Example #3

I_T:202 - R
O_T:022
Gt:352
Ab:292
60:140
SD:7 (w)
OH:001
OT:56
CG:345

G_{RB}: 14 left

If your aircraft does not have an RMI/HSI, then add an extra line to your PLOG Hold Planner, and when in the turn to the Inbound Track, monitor the aircraft heading on either the Direction Indicator ("DI") or the Garmin.

In the example on the right the extra line "60˚" has been added. (in purple on the right)

This is easily calculated (as in this example) as being

(I_T) 202˚ - 60˚ ≈140˚

Do not try to get too clever with this, just round the number up or down to the nearest 5˚, so in this example, the 60˚intercept is actually 142˚, but 140˚ is more than close enough.

Undershoot, Overshoot Management and the RBI in the Hold

Earlier we looked at the type of error called an "Undershoot" (Fig. 6.), take a moment ot revise this potential error. If your aircraft has an RMI (with an auto-slaving compass rose), then when an aircraft gets with 60˚of turn-remaining-to inbound, then the QDM to the Beacon can be directly read off of the instrument.

There is the added complication of NBD Dip on a ADF needle, but just deduct 10˚ when in a right-hand turn and add 10˚ to the needle position when in a left-hand turn.

When the aircraft does not have an RMI, then visually the situation becomes more challenging. There is some bad news and good news. The lack of direct readout of QDM, turbulence, induced needle wander and the general inaccuracy of an ADF on an RBI, mean you just have to work just a little bit harder. That's the bad news.

The good news is that your Examiner will equally have the same issue as you, and therefore will have difficult definitively reading off your exact QDM to the Beacon. Add to that, that the RBI is often on the far left-hand side of the Instrument panel, they will be suffering from extreme parallax error and will have great difficulty reading your QDM +/-10˚. This doesn't just apply to the Hold, but any ADF single-needle tracking.

Take the example below, this is a classic Undershoot setup.

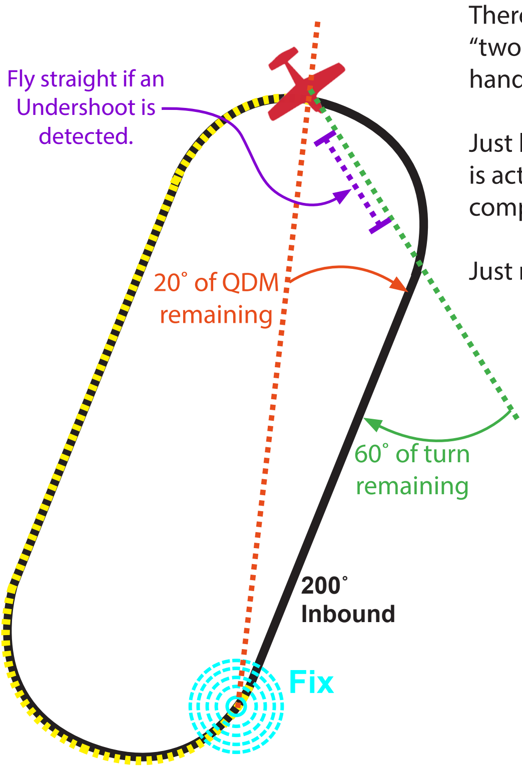
G5 with GPS Hdg

HSI with Mag Hdg

Firstly you will need a Heading source.
A Garmin G5 with magnetometer will give you Magnetic track. If not, then a GPS track readout , but with European Mag Deviation being +/-3˚, this can be effectively ignored.

Alternatively, your aircraft may be fitted with a HSI, which is auto slaving, or maybe you have a Compass and Direction Indicator. On the left, all three are reading ~150˚, the 60˚ of turn-to-go.

Whichever you have, you know when you are approaching the 60˚-to-go fix.



Have you realised yet that the "big numbers" on a Compass rose are at 30˚intervals? Therefore to visualise your "QDM-to-go", just look at the RBI to see if the needle is "two-big numbers" to the right of the top of the RBI (in a RH Hand turn, left in a left-hand hold).

Just look at the example below, you can see that the ADF needle (green arrow below) is actually pointing at 40˚, when it should be at 60˚. No maths required don't over complicate the problem.

Just roll out level, then fly straight to push the head towards 60˚on the RBI.

Now in the example shown here and if you have been paying attention, then you will realise that as soon as the wings go level, NDB Dip will disappear and the ADF needle will (in this case) point at 30˚

This is correct as the QDM is 150˚ + 30˚ = 200˚ which is the desired inbound QDM for this Hold.

Just "push the head" until the needle reads 60 to the right (light blue needle) and then continue the turn onto the Inbound Track

Undershoot, Overshoot Management and the RBI in the Hold (contd.)

Earlier we looked at the type of error called an "Overshoot" (Fig. 7.), take a moment to revise this potential error. If your aircraft has an RMI (with an auto-slaving compass rose), then when an aircraft gets with 60˚of turn-remaining-to inbound, then the QDM to the Beacon can be directly read off of the instrument.

There is the added complication of NBD Dip on a ADF needle, but just deduct 10˚ when in a right-hand turn and add 10˚ to the needle position when in a left-hand turn.

Take the example below, this is a classic Overshoot setup.

G5 with GPS Hdg

HSI with Mag Hdg

As in the previous example

The 60˚ turn-to-go fix is at ~150˚

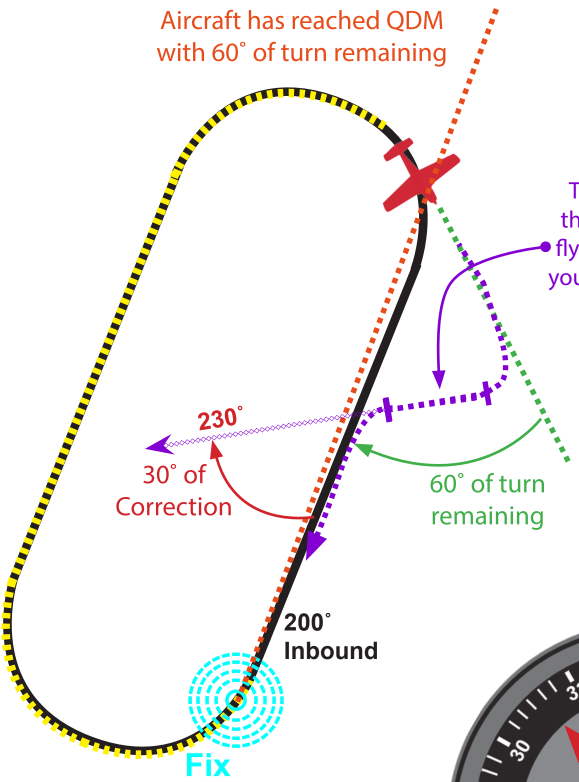
Just look at the example below, you can see that the ADF needle (green arrow below) is actually pointing at 80˚, when it should be at 60˚.

In this scenario you are going to fly through the Inbound QDM onto the "unprotected" side of the Hold.

Therefore, continue the rate-1 turn until you have a heading that is approximately 30˚ past the inbound Heading.

In the example below, the Inbound QDM is 200˚, therefore 200+30 = 230˚

Roll out on 230˚ which will push the head of the needle, back towards the 200˚ QDM, but how?



Well, from an initial heading of 150˚ (remember the 60˚-to-go-fix) around to 230˚is an 80˚ turn.

As a result of your turn, the ADF will have rotated and now point ~20˚-30˚ to the left (blue needle) depending of course on how far you Overshot by.

Let us assume the overshoot was 20˚

You are now intercepting the QDM at 30˚ so by doing so you are pushing the Head from 340˚ (blue needle) towards 330˚, which represents our 30˚ of intercept angle.

But WAIT!

The needle suffers Dip, so we need to actually fly an extra 10˚ to 320˚ to get to a Relative Bearing of 30˚ .

As soon as the needle reaches 320˚, start to turn left back onto the heading of 200˚ and you should have intercepted the Inbound QDM.

This is visualised on the right by the position of the red needle, just prior to turning left onto the Inbound track.

RBI Tracking

Don't be fooled into putting the Head of the needle onto 360˚ when tracking Inbound on a QDM to a Beacon or Fix, or 180˚ when tracking Outbound on a radial or QDR, as you may have a Wind Corrected Angle ("WCA") of drift angle applied.

Remember the RBI Compass Rose does not rotate. Therefore even if the aircraft is flying on a heading of <say> 239˚, the Compass card will always have North at the top.

Take the following examples.

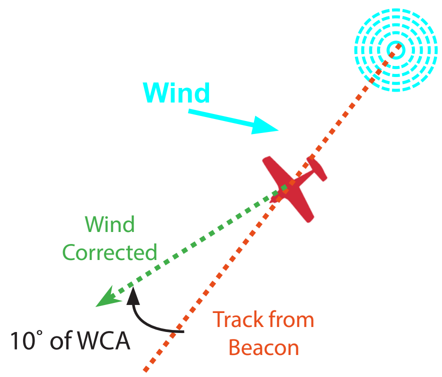
In the Fig 12. example, the aircraft is tracking away from the beacon with a track of aprox 240˚ the wind coming from the right.

The Pilot is applying 10˚ WCA to compensate for it.

As can be seen, the Relative Bearing is 170˚ and Relative Radial is 350˚.

Even though the aircraft is maintaining a constant track of 240˚, the ADF needle does not point to the back of the aircraft.

Fig: 12

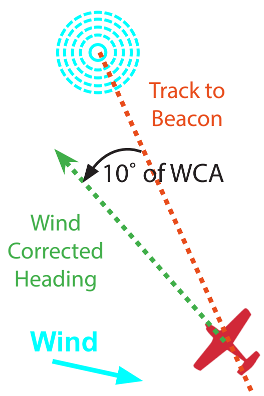


In Fig 13., the aircraft is required to track towards a Beacon with the wind coming from the left. The pilot is compensating with a 10˚ of WCA to the left accordingly.

As a result and as can be seen here, the Relative Bearing is therefore 010˚.

In both cases, if the WCA of 10˚ is correct for the strength of the wind and direction, then the QDM & QDR will remain stable, irrespective of flying towards the NDB beacon or away from it.

Fig: 13.



Relative Bearing Visualisation

This is a vital skill of any IR Pilot, and if you do not yet understand it or know how to apply it, then get RANT XL and practice, practice, practice until it "clicks".

I promise, if you put the effort in, one day it will suddenly all make sense and like riding a bike for the first without stabilisers, you will never go back.

Garmin Systems

Purple Bugs and The Pursuit of Happyness

The Garmin G5 has a built-in GPS. It is therefore able to give you GPS Track information. This is your Track over Ground, or TOG, which has been mentioned before. It does not matter what the wind is doing, how strong it is or in which direction, this is your actual flightpath over the planet as defined by WGS84.

The Garmin G5, also has an inbuilt electronic Compass, that can work independently of any Flux-Gate in the aircraft's wing, that may or may not been fitted. Not all G5's have this feature enabled, so check before flying. However, if you do fly behind a Garmin G5 and the Compass is enabled, your life just got a whole lot easier! *The following discussion assumes that the Compass feature is enabled.*

This is a typical G5, configured as an Attitude Indicator. The G5 is TSO 'd and can be used to directly to replace a vacuum-driven Attitude indicator, but also comes with extra features as can be seen from the display.

One of those features, which is part of the Compass ticker-tape along the top of the display is your magnetic heading, in the left-hand example, reading "225", or 225˚ Magnetic heading.

If this is the case, then you must realise that you now effectively have an electronic Direction Indicator, which is auto-aligning. *Light-bulb moment!*

Note, that there is a small magenta diamond to the right of the Compass ticker-tape at the 212˚ position. This is the Tracking Bug, it is indicating the track-over-ground as determined by the GPS receiver.

Second light-bulb moment! If we have a magnetic Heading of 225˚ and we have a TOG of 212˚, then by deduction we must have a wind drift of 13˚. What this means is that when flying in any given direction you can now read off the actual (*not a "guestimated"*) wind drift, <u>in real time</u>!

This can be used to much more accurately create triple-drift calculations as the Single-drift WCA is actually straight in front of you. A GPS-derived TOG also gives you Ground-speed. This is displayed in the bottom left-hand corner of the display. Need Headwind/Tailwind calculations for any given heading? Just deduct the GS from the ASI number.

In this photo, AS is 149Kts, GS is 150Kts, so a 1Kt tailwind.

This is where we find out who is pay attention, because wait, if we have a GPS-derived TOG, then we must also have a fully corrected wind angle? Indeed we do, and better than that, the GPS receiver is updated once per second, so this is the perfect tool for tracking a QDM, or QDR perfectly!

Quite simply, if you have a desired track to a Beacon (its desired QDM), then all you have to do is to turn the aircraft so that you match this QDM to the GPS-TOG, and you will fly directly to the beacon.

If you think about it, we normally start with a Heading, then Wind correct it for track, and the correction is always an estimate and we don't know if that estimate works until we have flown for a few minutes and re-assessed the progress.

Now we can bypass all of that. We decide what QDM we need, and turn the aircraft until that GPS magenta track bug matches the desired QDM. Then set the Heading bug to whatever heading is on the Compass display, and then fly this heading. QDR's are just the same, just set the magenta bug to the reciprocal of the desired QDR.
If you don't now have a grin from ear to ear, its probably because you don't understand the implications of this piece of equipment. A suggestion....... go back to the top and read this page again!

Garmin Systems (contd.)

Where an Attitude Indicator is removed and replaced by a Garmin G5, then that usually only leaves the Direction Indicator as the remaining vacuum-driven instrument. *(For reasons of single-point failure resilience, Turn Co-ordinators and Turn Indicators should be electric.)*

For this reason it is common that if the AI is replaced the DI is removed at the same time. This saves not just 2x Kgs of instrument weight, but also the removal fo the vacuum pump (1.5Kgs plus associated plumbing) and sometimes an electrical auxiliary vacuum pump as well. (another 3 Kgs).

The smart move is to fit a second G5 slaved to the top unit so they can share common information and a data bus.

The Navigation unit, can be configured to act as a GNSS RNAV unit, a VOR OBI, a VOR RMI, an ILS LOC/GS or even an RNP display.

The actual capability will depend on the avionics fit of your particular aircraft, so take some time to research what is fitted.

The radio-nav information can be turned off (see bottom left) so that the display only offers an auto- aligning compass rose.

Here you can see more clearly the GPS-TOG track and bug (dotted white line, magenta triangle). The set Heading Bug (cyan) and ground speed.

The G5 is a very powerful piece of equipment. There are simulator programs available to enable you to train on the ground how to use them. Ask your instructor where you can do this and don't forget to buy them a coffee.

Test Limits

In the IR skills test, the Hold Section has a number of limits, which if flight occurs outside of these limits, invites at best the increased scrutiny of the Examiner, or worse the application of a "partial" or if particularly unsafe, a Fail.

If you think your instructor is nagging you in your lessons, then that is probably for a reason, so stop arguing with them and learn what you have done wrong.

Single-Needle Tracking: Inbound QDM #1

Most of the IR test is like a well-choreographed dance, with certain things happening at predictable times.

Not so the Single-Needle tracking. This creeps up on the student when not expecting it, and usually takes the form of an ATC request "route direct to XXX". At this point the student tunes, idents, select the correct mode and turns towards the Beacon or fix. IF test pecifications state that Tracking must be achined to an accuracy of +/-5˚.

Without you knowing it, the Examiner will wait until you have gone wings-level towards the Beacon, pauses for a few seconds then notes down the inbound QDM.

This is now the target QDM that you must maintain +/-5˚ all the way to the beacon.

Do not home towards it, but track with a wind corrected heading.

A Garmin G5 will help you with this, if having gone wings-level, and set up a WCA, properly bugged it, you casually mention the fact that you have "*selected a WCA to account for the wind for a QDM of xxx to the beacon zzz*" , you will send the Examiner back to sleep as they now know you are wise to their monitoring of you.

Monitor the Head of the Needle, and remember "***push the head, pull the tail***".

If the needle Head starts to move away from your heading, and therefore your desired QDM, then you are apply too much "push", so turn towards the Head, and reduce the "push" angle. If the Head moves off of the desired QDM towards your heading, then turn away, and increase the Push-angle to push the Head back.

Conversely, if on a QDR, the tail moves away off of the QDR and away from your Heading, turn away from the tail to "Pull" it more back towards the QDR.
If the Tail starts to move towards your Heading, then turn towards it, in other words reduce the angle of "Pull" so you are not "pulling" it so hard.

Inbound Planning

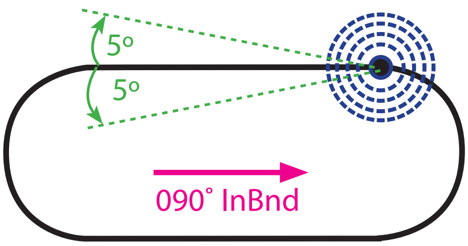
There is a good chance that the Beacon you are single-needle tracking to is also the Hold Fix, which can also double-up as the Intermediate Approach Fix ("IAF")
Not necessarily a pass/fail item this, but if whilst Inbound to the Beacon/Fix, with a good 10minutes before reaching the fix, start on planning the Hold, using the actual wind you are getting in-flight.

This will do three things.

1. Prepare you for the Hold
2. Act as a reminder of what you about to do, and refresh your memory of the Hold
3. Demonstrate to the Examiner that you are planning ahead, so they can relax and go back to looking out the window and not on your progress (*or perhaps that QDM you were supposed by tracking by +/-5˚ has now become 10˚!*)

Entering the Hold: Inbound QDM #2

The Inbound track to the Hold must be flown to within 5˚of the QDM if a Beacon or DTK if it is a Fix.
This is number, so it is not open to interpretation by the Examiner.



Work at it. When entering the Hold, or when coming back round the Inbound turn, deal with any Under/Overshoot and get back with +/-5˚ QDM before passing the Beacon

Platforms

At some stage in the Hold, if it is an Intermediate Fix, then you may be told to descend to the Platform altitude for the Approach served by the Beacon. Platforms are there for a reason, to provide minimum obstacle clearance. Treat them with respect and don't bust below them.

Platforms are made of concrete!

So fly 50-60' above them and never get below them. So, for a Platform of 1800', fly at 1850'.
Bust a Platform once the Examiner takes notice. Bust it again and don't do anything, its a partial. Bust it a third time or at anytime by more than 100' its a fail. No "if's, no "but's" and no argument.

Fully Worked Example

Lets have a look at a fully worked example of a Hold plan, start to finish.

Exercise

You need to hold at the EVA on 329Khz, which is a left-hand Hold, Inbound is 120˚, the predicted W/V is 100/18, Aircraft TAS=105Kts. Heading is 035˚ towards the Beacon. Plan the Hold and Entry.

Hold Example #3

IT: *120 - L*
OT: *300*
Gt: *330*
Ab: *030*
60: *180*
SD: *3 (e)*
OH: *309*
OT: *48*
CG: *333*

G_{RB}: *22 right*

Start by filling in the Green data, **I**nbound **T**rack, **IT,** is 120 - L(eft)
Outbound **T**rack is 120+200=>320 - 20 =>300, so **OT** = 300
Ga**t**e is 300 + 30 (its a left hand hold!), so **Gt** = 330
Abeam Fix is **IT** - 90 (again for a left hand), so 120-90=030˚, therefore Ab = 30
60˚ Inbound Turn Fix will be 120 + 60 (left hand again), so 180˚

So far so good, just simple arithmetic.

MDS is again easy...
60=18, 120=9, so 90=12, so for 105Kts call it 11˚

Single Drift Inbound, W/V is 100, IT=20, so clock code 1/3rd, 1/3rd of 11 is about 3˚. So Single Drift correction is 3˚ East. Put that next to **SD.**

The wind is blowing the aircraft into the hold, so In-Hold wind, so use triple-drift. 3x 3˚ = 9˚, so **O**utbound **H**eading, **OH**, is OT+9˚, so 300+9 = 309.

Write down 309 next to OH, so your Outbound, wind corrected heading will be 309˚

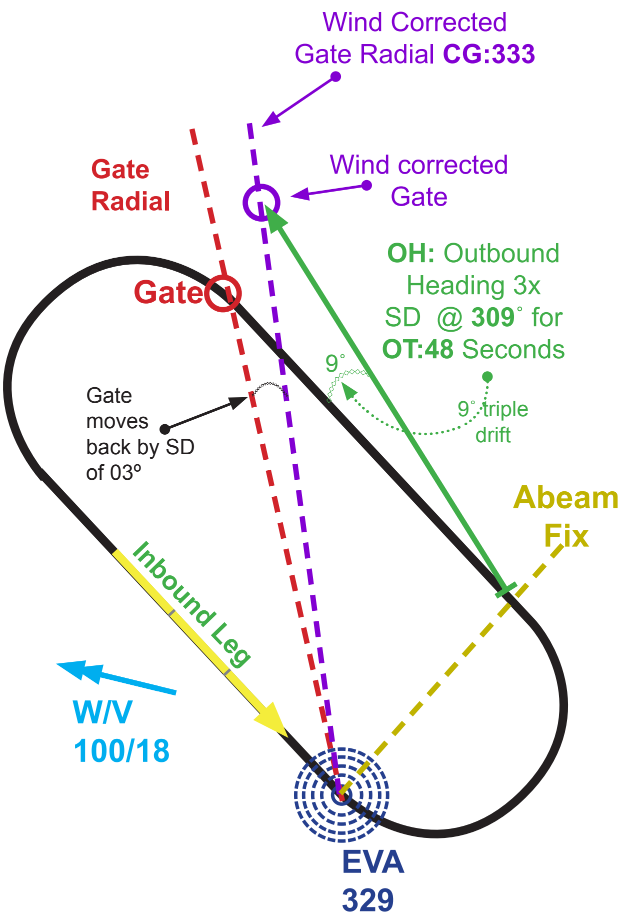
Timing. When on the Outbound, the wind will be 20˚ from behind you at 18Kts.

Starting from 12 o'clock, work anticlockwise to 20mins, this is in the 3/4 quadrant, therefore 3/4 x 18 = 12Kts of tailwind.

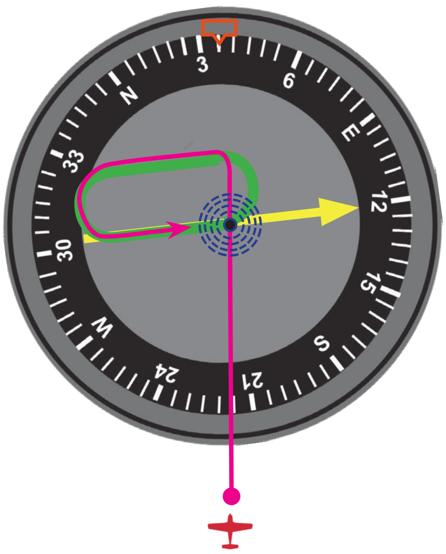
So instead of a 60second outbound track, take off 12 seconds, so **O**utbound **T**ime is
60-12 = 48 seconds. So for **OT**, write 48.

It is an In-Hold wind, so bring the Gate back by Single Drift (SD), already calculated, so Gate is now 330 + 3, as it is a Left-hand Hold, so **C**orrected **G**ate, **CG** is 333.

Finally if you are using an RBI, then the **G**ate Corrected **R**elative **B**earing, G_{RB} will be OH - CG, 309-333=>-22, so 22˚ to the right of the top of the RBI. G_{RB} = 22˚ right



The above illustration shows the approximate corrections to be made. Angles have been exaggerated for clarity



Fully Worked Example (contd.)

The top image illustrates what you would see in the cockpit on the instruments as you approach the hold on a QDM of 035˚ with the CDI "bugged" onto the Inbound radial of the Hold of 120˚.

Even though you may have already completed the Hold calculations, to help you visualise what is going on, try to imagine the Hold.

The lower image shows how by overlaying an imaginary beacon and the hold onto the face of the HSI, how easy it is to visualise the Entry and to act as gross-error check on your calculations.

In this example, you can see that the entry will be a Direct >90˚ but less than 180˚

You can also visually check the calculated Corrected Gate and the wind-corrected Outbound Heading, making it less likely you have made any major mistakes.

Practice & Revision

The example above, requires a fair bit of thought the first time you do it. However the more you practice the faster it will become and more intuitive. Eventually you will be able to "see" the Hold floating on top of your Instruments and the calculations will become almost automatic.

To get there though, requires practice. A lot of it!

For every hour in the SIM, you should spend at least an additional hour on revision and homework.

There is a piece of software called RANT XL. Buy it! It will cost you £80 if you buy direct and will save you a lot more money later on. It will allow you practice exactly this type of scenario, for a fraction of the cost of a Simulator lesson, and also at your convenience.

RANT XL is a procedural trainer. Unlike MS Flight Simulator or X-Plane where the emphasis is on handling skills, RANT is about learning how to Intercept, Track and fly Holds. Turning climbing and descending are done with single keyboard presses, so you can concentrate on the "radio picture".

As an aspiring IR candidate, you should budget at least 40 minutes per day on RANT XL, mastering the various skills of Applied IF.

Once you have got to the stage of learning Holds, the best exercise you can "fly" is the "*random-wind, random position, random beacon, intercept and fly a hold*" exercise.

Think of it this way. If over the course of your IR course if you can save 10 minutes of flying in the Seneca as a result of using RANT XL, it will have paid for itself. If you save one extra SIM lesson of one hour it has paid for itself.

Ask your Instructor for a demonstration, and you will understand not only what is expected of you, but the accuracy and speed needed to be successful. You now owe your IR instructor a small case of beer!
Money well spent.

Conducting the Hold

A Hold will usually (hopefully?) terminate with an Approach. However before you start an approach and leaving the safety and comfort of the Hold, you need to prepare for the Approach. Given that this preparation will be done whilst flying the Hold, we are including it here.

The Approach Ban (EASA)

" The commander or the pilot to whom conduct of the flight has been delegated may commence an instrument approach regardless of the reported RVR/VIS.
If the reported RVR/VIS is less than the applicable minimum the approach shall not be continued: (1) below 1 000 ft above the aerodrome; or
(2) into the final approach segment in the case where the DA/H or MDA/H is more than 1 000 ft above the aerodrome.
d) If, after passing 1 000 ft above the aerodrome, the reported RVR/VIS falls below the applicable minimum, the approach may be continued to DA/H or MDA/

In normal flight operations one would not volunteer to fly a Hold, but fly radar vectors or a procedural STAR, straight to the appropriate Approach. However as you are "on-test", you will be asking to take up a hold for the purposes of the test. As a result, you will be asked by ATC to "*report when ready for the Approach*".

Before you can ask for an Approach, you need to demonstrate that you have considered the possibility of an Approach Ban and have briefed yourself on the weather conditions at the Airport.

Before we start, it is worth noting that it is considered poor airmanship to make an approach when the reported cloudbase and visibility for the airport are below the minimas.
Ryanair with coupled approach autopilot, multi-pilot crew and automated TOGO capability, may elect to "give it a go". But not us, not single-pilot, no autopilot-coupling, manually flown and manual power.

For us we have the Approach Ban as a safety feature, and for Jerez it can be summed up as this:

- The Airport altitude is 93' AMSL
- Add 1000' to this and round it up to the nearest 100', so 1000 +93 =>**1100'**
- If the reported RVR is below minimas for the approach, you cannot descend below 1100' on the Approach and must initiate a Go-Around (and presumably return to the Beacon for a Hold)
- If however, the RVR is reported as being better than minimas on reaching 1100', you can continue the Approach below 1100'
- **But** ,if after passing below 1100' , the RVR reduces below minimas, then you may continue the Approach to DA/MDA.

RVR Minimas
The RVR for an Approach is given on the Approach Plate and will always be the highest of the most limiting factor.

For Example #1 ILS Z Approach RW20 LEJR

Cat A/B: With Flight Director/Auto Pilot	550m
Cat A/B: No Flight Director / AutoPilot	750m
All Cats: Single Pilot Ops, no coupled Autopilot	800m (*this limit applies to all airports*)

Therefore flying without coupled Autopilot, in a Single-Pilot operation the RVR Minima is 800m

Conducting the Hold (contd.)

Example #2   VOR Approach RW20 LEJR

Cat A/B: No equip. concessions granted	1500m
All Cats: Single Pilot Ops, no coupled Autopilot	800m

Therefore the absolute RVR minima for the RW20 VOR App is 1500m.

Planning the Approach

Working backwards, you cannot start an Approach unless above limits, therefore you cannot ask ATC that you are ready to start an Approach if you can't fly it.

You can't make that decision without knowing the current RVR, so the first thing you must do before asking to leave the Hold is to **get some fresh ATIS !**

The ATIS will tell you what the Cloudbase is, so you can decide if the cloudbase is above DA/MDA.

The ATIS will report the RVR, so you can decide if it is above the limits from the Approach Plate.

Now you can make a decision, inform the Examiner that "*Cloudbase and RVR are above limits, no Approach Ban in place*" then push the PTT and tell ATC that you are ready for the approach.

At the same time, if you are really "on the ball" why not check your Missed Approach Instructions?

So be efficient and make a single full call to ATC something like this:

> "*Sherry 63, ready for the Approach, ILS Y RW20 at Jerez, request missed Approach instructions, QHN1xxx*"

This tells them you are ready to go, that no Approach Ban is in place and it prompts ATC to give you your M/App instructions.

If ATC forget to give you instructions (they sometimes do), then brief yourself on and be prepared to fly the standard M/App Proc, whilst also getting a thumbs-up from your examiner for asking.

In some busy environments, it is not unusual that once you are established on the Approach and have been asked to contact the Tower, that it is the Tower that passes the M/App instructions to you, so be ready for this.

Conclusion and Further Resources

This document is not exhaustive and under constant review as the author finds better ways to teach his students and learns from their mistakes so he can assist others in not making them.
This document is therefore the culmination of watching and learning from my students and is work-in-progress.

Humility is the key to learning, and I am keen to keep learning. So any suggestions or criticism of the document are very welcome. My eMail is available on my Web Site, *seek and ye shall find.*

RANT XL

RANT XL can be downloaded from www.oddsoft.com . There is a trial version available, the full version (*at time of writing)* is £80. The author can get a discount for Students, ask before making a full purchase.

The author of this manual has also successfully installed RANT XL on a Macintosh (Intel) without needing to install a windows Virtual Machine and accompanying Windows OS. Approach the Author if your flavour of fruit is Apple.

Approach Plates

All of the official Approach Plates are available from the AIP of the relevant country.
For Spain they are available from Enaire. Here for example, are the plates for LEJR (Jerez):

https://aip.enaire.es/AIP/AIP-en.html#LEJR

Download and print the plates you are most likely to use and study them.

Do not memorise them as they get changed regularly and the data will change. By studying them, I mean understand every piece of information on the Plate.

If you don't know what something means, go look it up. Be a "*miner for truth*" and prepare yourself for using them in anger, by analysing and understanding what they are telling you.

Other Resources

The author runs his own web site with more support manuals for practical Applied IF flying from this series.

http://www.evansabove.us

for more information, including an IR PLOG, setup with all the information and check-lists to keep you on-track.

Ask your Instructor

There is no such thing as a stupid question, so not be afraid to ask questions and seek help and assistance. That is what your Instructor is for!

Your IR Instructor is trying to assist you in passing what could be the hardest flying exam you ever take. Use their knowledge, listen to what they say, soak up their advice and be thankful for their time.

On passing my ME-IR, I bought my IR Instructor, Jon O. his "*favourite poison*", a 12-pack case of Guinness.
If this document was useful to you, mine is Wychwood's Hobgoblin, if you're asking.... !!

Stephen R.S. Evans
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