



Visual Navigation

Practical Flying Guide 1

Version 1.0 - February 2022

Foreward

The Practical Flying Guides aim to bring together the practical elements of a particular topic. In this case Visual Navigation. This guide is not academic in nature, but utilises simple methods with relevant under-pinning theory and best practice, with the aim of providing useful guidance to be used for flying.

Contents

| | |
|---|-----------|
| Foreward..... | 1 |
| Introduction | 3 |
| Practical Navigation | 3 |
| Arrangement of the Guide | 3 |
| Planning and Preparation | 4 |
| Choice of Maps | 4 |
| Plan the Route..... | 4 |
| Study the Route | 5 |
| On the Day | 5 |
| Navigation Techniques | 7 |
| Dead Reckoning | 7 |
| Heading | 7 |
| Time | 9 |
| Flying the Route | 11 |
| Flying a Leg..... | 11 |
| Avoiding Weather | 12 |
| Managing Workload..... | 13 |
| Departure and Arrivals..... | 13 |
| Departures | 13 |
| Arrivals | 14 |
| Map reading..... | 14 |
| Fixes | 15 |
| Choice of Fixes | 15 |
| Using the map when airborne..... | 17 |
| Diversions..... | 18 |
| Estimating Track..... | 19 |
| Calculating Drift and Head/Tail Wind..... | 19 |
| Diversion Planning | 20 |
| Lost procedure | 22 |
| Initial Actions | 22 |
| Subsequent Actions | 22 |
| Inadvertent Entry to IMC | 23 |
| Avoiding IMC..... | 23 |
| Recognition of Inadvertent Entry to IMC | 24 |
| Maintaining Control | 24 |
| Exiting IMC | 24 |
| Further Action | 25 |

| | |
|------------------------------|---------------|
| Night Navigation..... | 24 |
| Planning | 26 |
| Map Reading..... | 26 |
| Airborne | 26 |
| Using GNSS..... | 27 |
| GNSS as an "Aid" | 27 |
| The Challenges | 27 |
| Successful GNSS Usage..... | 28 |
| Conclusion | 28 |
| Appendix 1..... | 29 |
| Example Navigation Log..... | 29 |



Cover photo: [iStock.com/mikulas1](https://www.istock.com/mikulas1)

Inside photo [iStock.com/jacoblund](https://www.istock.com/jacoblund)

Introduction

This guide is meant for as wide an audience as possible. It can be used during navigation training, but equally as a refresher long after training has been completed. It is not mandatory in its nature, nor an acceptable means of compliance, but a set of practical techniques that can be copied or adapted as required.

Practical Navigation

The purpose of this guide is to explain the “practical” airborne techniques and methodology of visual navigation. There are many publications that explain the under-pinning theory and knowledge that supports practical navigation, but this text assumes that knowledge already exists, and so lengthy explanations are avoided.

Practical navigation is a simplified application of these navigation principles, designed for single-pilot operations. Using a calculated and structured method of navigation avoids the need to “feature crawl” or follow progress with a finger on the map, with the resulting “head down” time. In-fact the map can be put away for relatively long periods, allowing time for a thorough lookout, in-flight tasks, improved situational awareness, and accurate flying. In-flight the use of mental arithmetic is very simple, navigation equipment is kept to a minimum, and the extensive use of “estimation” is used, backed up by “gross-error” checks.

With the introduction of excellent technologies, it’s a common misconception that visual navigation techniques have been made obsolete. Whilst navigation is the topic of consideration, the techniques described in this guide are designed to ensure proper integration of all aspects of safely operating an aircraft during a cross-country flight. The routines and workflows acquired for visual navigation transfer well into instrument navigation and assist in developing non-technical skills such as workload management, task prioritisation, situational awareness and decision making. As such, the principle of these routines and workflows remain highly relevant throughout any pilot’s career.

Arrangement of the Guide

The guide is arranged in the order of a typical cross-country flight. The first section begins with *Planning and Preparation*, and as mentioned above, assumes some basic prior knowledge.

The next section, *Navigation Techniques*, explains the dead reckoning methods used for navigating. In *Flying the Route*, examples are given of how these techniques are applied in practise. These two sections combined are the most important parts of this guide, as they describe the key principles of successful visual navigation.

The next sections are *Departures and Arrivals*, and *Map Reading*. The next three sections; *Diversions*, *Lost Procedure* and *Inadvertent Entry into IMC (Instrument Meteorological Conditions)* deal with some potential difficulties that may arise during a cross-country flight.

The two final sections provide supplementary material for *Night Navigation*, and *Using GNSS*.

The guide predominantly refers to use of aeronautical charts and maps in paper format. It is recognised that there are many types of electronic devices which can also be used for visual navigation, but advice for these devices has not been included in detail in this guide. However, it is important to note that if using these devices, they must be very well managed as they can create a distraction, disrupt workflow and often increase workload.

Planning and Preparation

The key to a smooth and well flown cross-country flight is meticulous pre-flight planning and thorough study of the route to be flown. Most of this work can be done several days in advance, leaving the calculation of heading, groundspeed, and times to the day of the flight once the winds are known.

The principle being that the more carefully prepared the pilot is, the smoother and easier it will go in the air. Therefore, time spent preparing on the ground is very valuable. As a guide, in the initial stages of training, planning and preparation could easily take double the time of the actual flight. This will reduce as experience is gained, but good preparation always takes time.

Choice of Maps

It is essential to use appropriate and up to date aeronautical charts or maps. Where a digital map is used, the equivalent paper copy should be referred to in order to verify the accuracy of information.

Generally, the Visual Navigation Charts (VNC) with scales of 1:500,000 and 1:250,000 are used for visual navigation. The 1:500,000 VNC being used for planning, drawing on the route to be flown, and for most of the map reading whilst airborne. However, it only shows selected aeronautical information. For complete aeronautical information the 1:250,000 VNC must be used for both planning and referred to whilst airborne.

Whilst these two maps cover most visual navigation requirements, there are other aeronautical charts available and these are listed in the AIP. In addition, for more specialised requirements other maps or charts may be required, for instance the LINZ (Land Information New Zealand) maps for helicopter operations.

Plan the Route

Planning starts by selecting the route. The pilot will choose a route, taking into account controlled airspace, restricted areas, danger areas and other areas which could present a hazard to the safe conduct of the flight i.e. parachute jump zones, glider launch sites, bird sanctuaries etc. The chosen route is plotted on the map, and track lines are drawn. The aim of all subsequent navigation is to maintain the chosen track as accurately as possible. An appropriate Start Point is chosen close to the airfield. In the case of controlled aerodromes, the Start Point would logically be a VRP at the completion of a published departure procedure. The track lines stop short of the Start Point, Turning Point, and destination, so as not to obscure important details on the map. A circle is drawn around the Start Point, Turning Points and destination. Fixes need to be chosen, at intervals equating to approximately 6 to 8 minutes flying time. Ideally, they should be evenly spaced along the track and be sufficiently distinctive to enable easy identification from the air. It is not always possible to find fixes to meet these requirements, in which case a sensible compromise will be suitable biased toward ease of identification. There should be a break in the track line at the fixes, so as not to obscure features on the map. Fan lines can be added for each leg to assist in estimating any track error. These originate at the Start Point for each leg and are usually 10° . Fan lines need only be drawn on one side of the track, as most people can estimate a track error on the opposite side using the same fan line. If practical it is worth placing the fan line on the downwind side of the track, as this is the most likely side for a potential track error.

The tracks, distances and altitudes can be measured and entered into the Navigation Log, with true track converted to magnetic track. An example Navigation Log can be found at Appendix 1. Next, note which areas the route will pass through or over, and all the things to be considered such as airspace, other airfields, danger or restricted areas. The AIP and supplements should be referred to for all these details. The base altitude of the relevant controlled airspace should be noted. The applicable radio frequencies should be written down for ATC, CFZ's or MBZ's, including the FISCOM frequencies for the area to be flown in. It is also important to note which Area QNH Zones will be entered, so that the pilot can request the appropriate Area QNH.

In addition, a Minimum Safe Altitude (MSA) should be determined for each leg of the route and noted on the Navigation Log. This is calculated by searching for the highest obstacle 5nm either side of the track, including 5nm beyond the Turning Points or Destination, rounding the altitude of the obstacle up to the nearest 100ft, and then adding 1000ft, or 2000ft if over mountainous terrain. As the flight is under VFR, it will often proceed at a lower altitude, but if an inadvertent entry into instrument meteorological conditions (IMC) occurs (discussed later), the MSA is already planned. An alternative method is to use the Maximum Elevation Figures (MEFs) from the map, and then add 1000ft, or 2000ft respectively, but this usually results in a much higher MSA and reduces the chances of exiting the cloud.

It's a good idea to plan a "Minimum VFR Altitude to Continue" for each leg of the route and note it down in the Navigation Log, as changes in the weather can be quite subtle. Once airborne, this can act as a "trigger" to alert the pilot to the fact they may have descended due to a lowering cloud base, and that positive action needs to be taken, such as diverting. The altitude chosen will need to consider the experience level of the pilot, being very conservative for student pilots.

If another airfield is to be visited then a study of the AIP is necessary, including any frequencies, VRPs, arrival procedures, runways and circuit direction. In addition, the layout of the airfield, taxiways and holding points, fuel availability and parking should all be checked, and the anticipated route from touchdown to parking should be reviewed.

The pilot should have in mind some alternative plans, including airfields, in case the route cannot be flown for some reason. Unexpected weather conditions being the most common.

Study the Route

Finally, a close study of the route and imagining how the flight will proceed will be highly beneficial. Try to visualise how the surrounding terrain and ground features might look from the air. Imagine the time available and work out the order of events and workflows, as previously described, considering when to focus on navigation and when to focus on the other important tasks.

The more preparation can be done on the ground prior to departure, the easier it will be in the air.

On the Day

All the planning described so far can be done ahead of the flight. On the day of the flight, weather and NOTAMs must be checked, and any necessary changes to the plan can be made. With the forecast winds the Navigation Log can be completed, and 6-minute markers drawn on the map (these will be explained in the next section).

Fuel planning, mass and balance, performance calculations, SARTIME and filing of a flight plan (if required) need to be included as part of the preparation.

During flight planning the average wind for the planned altitude for the flight should be drawn onto the map in degrees true and written in degrees magnetic. Immediately below write on the maximum drift that might be expected throughout the flight. The reason for this will become apparent when discussing diversions later.

The maximum drift would occur when the aircraft flies perpendicular to the wind and is derived from the 1:60 rule.

$$\text{Max Drift} = \frac{\text{Wind Speed (kts)}}{\text{TAS nm/mins}}$$

For example, with a wind speed of 10kts and a TAS of 120kts;

$$\begin{aligned} \text{Max Drift} &= 10 \div 2 \\ &= 5^\circ \end{aligned}$$

Figure 1 shows an example of a 1:500,000 VNC chart, prepared for a typical triangular route. Note the circles around the Start and Turning Points, as well as gaps in the track lines where fixes have been chosen. This ensures the features needed for identification are clearly visible. Fan lines have been drawn, for each leg, on the downwind side, as well as 6-minute markers. The wind is drawn in degrees True, but written in degrees Magnetic, and maximum drift has been written on to the map as well.

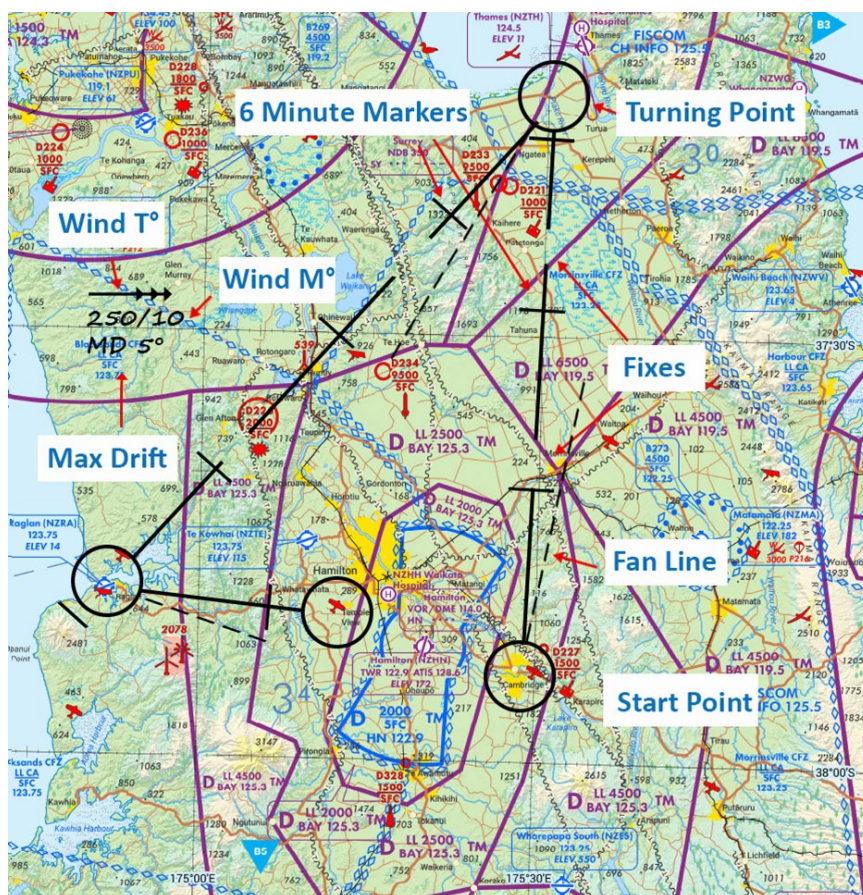


Figure 1 - Prepared Map – NOT TO BE USED FOR NAVIGATIONAL PURPOSES

Navigation Techniques

This section describes navigation techniques suitable for a visual cross-country flight. It begins with a brief description of Dead Reckoning (DR), followed by methods to maintain a track and manage time including adjustments for changes or errors that may occur.

Dead Reckoning

Dead reckoning is the process of navigating based on simple calculations, estimation and logic. Whilst a map is used for planning and to check progress in flight, dead reckoning is not navigating by following a map. Indeed, as previously mentioned, the map will be put away for relatively long periods. This is an important point to appreciate, as it will result in more accurate flying, greater situational awareness and less chance of becoming lost or disorientated.

However, the techniques described in this section need to be followed rigorously, for them to work. Self-discipline and good workload management will be needed, and these are described in the next section *Flying the Route*.

Successful navigation will be achieved if the heading is maintained accurately to achieve the desired track, and the time is properly managed as a means of measuring distance.

TIME – MAP – GROUND

As navigation is a time-based activity, time can be used to enhance use of the map when checking progress in flight, using;

TIME – MAP - GROUND

When the map is referred to, perhaps approaching a fix, it is first viewed in the context of the elapsed time since the last position check (TIME). This provides an approximate location along the track, where the expected features depicted on the map can be reviewed (MAP). Then these features can be compared to the features seen on the ground (GROUND). This method will reduce the chances of mis-identification of features, and is a more efficient way of using the map, taking less time. It is also a very good tool when dis-orientated as the time gives an approximate position along track, which is particularly helpful over featureless terrain.

Heading

At the planning and preparation phase, the desired true track will be measured from the map, and then converted to a magnetic track by applying variation. Compass deviation can then be applied to improve accuracy. Adjustment for wind is calculated using a navigation computer. This results in the magnetic heading required to achieve the desired track.

In-flight it is vital the pilot maintains this heading. Of course, even with accurate flying the aircraft may drift off track due to changes in the wind. The tracking is normally checked at pre-planned points or fixes. There are many methods for correcting track error utilising dead reckoning and the 1 in 60 rule. In this text we consider only one method, which requires the simplest of calculations whilst airborne.

If the aircraft is found to be off-track, a track error exists, and the pilot must first consider what might be the cause. Has the D.I. been properly aligned? Has the heading been diligently maintained? Was

the aircraft on-track at the start of the leg? Was any action, such as avoiding other traffic, taken which might have caused the track error? If one of these issues is identified, then the error is a “one-off” and not cumulative. The heading should not be changed, and track should be regained (discussed shortly). If the cause cannot be attributed to any action or in-action by the pilot, then it is likely to have been caused by a change in the wind and, if remaining un-corrected, will be cumulative as progress continues along the leg. A heading correction will be needed to remove the track error (TE). With fan lines drawn on the map against the track line at 10°, the pilot would only have to locate position on the map and be able to visually assess the TE in terms of degrees.

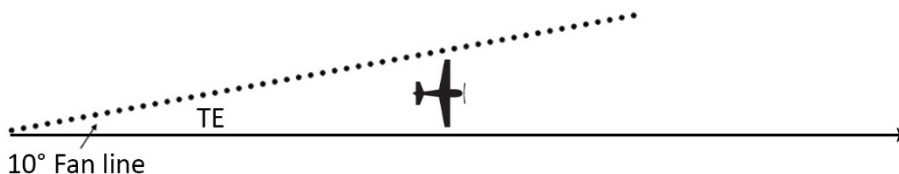


Figure 2 - Fan Lines

In Figure 2, without any calculation, the pilot can estimate the TE as 5° to the left. By correcting the heading 5° to the right the error is removed, and the desired track will be paralleled. The new heading is noted on the Navigation Log.

With the TE removed, the pilot now needs to regain track, and for that can utilise the Standard Closing Angle (SCA) method. This is based on the 1 in 60 rule and is a closing angle based on the speed of the aircraft.

$$\text{SCA} = \frac{60}{\text{TAS nm/min}}$$

As an example, an aircraft with a TAS of 90kts would travel at 1.5nm/min (90 ÷ 60 (min) = 1.5).

Therefore:

$$\begin{aligned} \text{SCA} &= \frac{60}{1.5} \\ &= 40^\circ \end{aligned}$$

So, applying the above formula, at a TAS of 90kts, the standard closing angle will be 40°. If another aircraft cruises at a TAS of 120kts, the standard closing angle would be 30°. This simple calculation is completed before flight.

The pilot should also estimate the distance off track. This can be done in a similar way to estimating spacing when downwind in the circuit. The downwind leg is usually flown at 1 nm from the runway at 1000ft agl, and is often taught to be judged using a point on the aircraft, for example 1/3rd of the way down the wing strut on a high wing aircraft, or in line with a fuel cap on a low wing aircraft. This method can be used using the same point on the aircraft, taking into account height above the ground. Therefore, if the ground feature lines up with this point, the distance is 1nm for every 1000ft agl. And at 3000ft agl, the distance will be 3nm.

In Figure 3, the track is regained by applying the SCA to the heading for the same number of minutes as nautical miles off track. For instance; off track by 2 nm, fly SCA for 2 minutes.

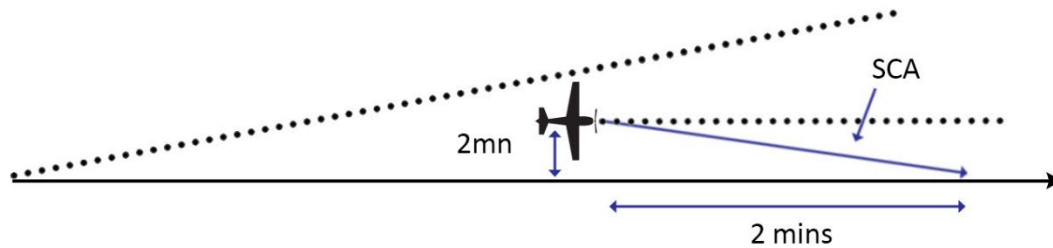


Figure 3 - Standard Closing Angle

Once the 2 minutes have elapsed, return to the new heading which was already re-calculated using the TE.

To summarise:

1. Maintain the calculated heading
2. If off track at a fix, determine if due to a wind change
3. If wind, assess track error and remove the error by amending the heading
4. Determine how many miles off track, and then apply the SCA technique for 1 min each nm off track
5. Resume the new heading as calculated in step 3

Time

Similar to Heading, there are many methods of using time in dead reckoning navigation. In this text we only consider one method, which again requires very simple calculations whilst airborne.

At the planning stage, once a track line has been drawn onto the map between a Start Point (SP), Turning Point (TP) or Destination, time markers can be added. These are 6-minute markers shown in Figure 4. The reason for using 6-minute markers is that they are very easy to calculate;

$$6 \text{ minutes} = \frac{\text{Groundspeed}}{10}$$

Therefore, for a groundspeed of 80kts, 8nm will be flown every 6 minutes.

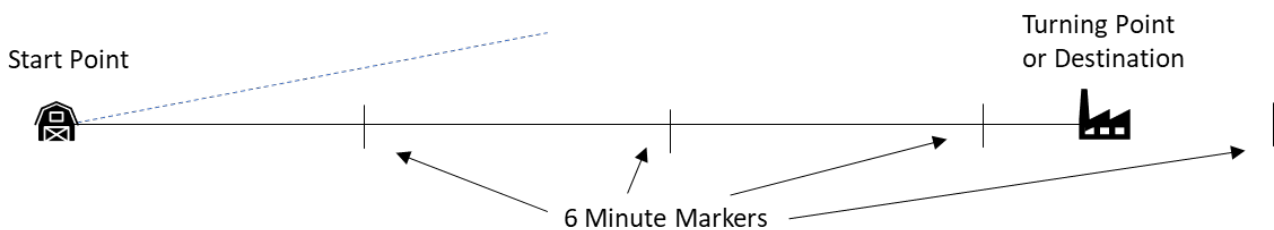


Figure 4 - 6-Minute Markers

Notice that the markers continue past the Turning Point or Destination. These 6-minute markers now give a visual time scale and can be used to great effect in several ways. Of course, an accurate watch or timepiece must be available.

- With the time overhead the Start Point noted down on the Navigation Log, it can immediately be seen that the elapsed time to the TP or Destination in Figure 4 is 21 minutes. This added to the time overhead the Start Point will give the ETA.

- During the planning phase, suitable fixes will have been chosen in order to assess the tracking and from where corrections to heading, if necessary, can be made as described previously. It is usually best to choose fixes 6 to 8 minutes apart. In flight the elapsed time and ETA to these fixes, can be easily estimated from the map. In Figure 5, it can be seen that the first fix will be reached 7 minutes after the SP, and the second fix after 14 minutes.

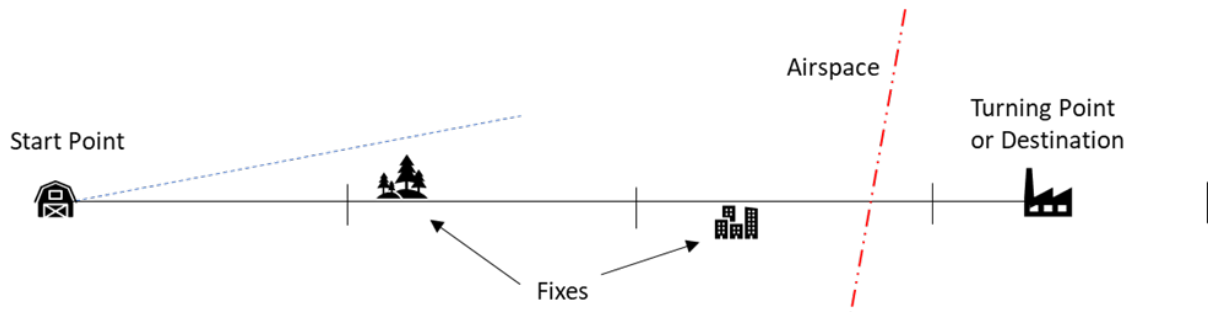


Figure 5 - Estimating Time

- If flying over relatively featureless terrain, as long as the heading is maintained, the aircraft's position can be easily estimated using the time scale.
- Airspace boundaries are not always easy to determine from ground features. As long as the heading is maintained, the position of an airspace boundary can also be easily estimated using the time scale. In Figure 5 the airspace boundary would be reached 16 minutes after the Start Point.
- A timeframe assists in the planning of workload throughout the flight. It can be seen that navigational tasks will be required at the Start Point, fixes and Turning Point or Destination. However, in between these points the pilot can plan on accurate flying of the aircraft, looking out, maintaining situational awareness, and other important tasks such as Cruise Checks or radio calls.

If the wind were to change during the flight, then this would affect timing, and ETAs would need to be adjusted. Timing would normally be checked at the pre-planned fixes. If there is an error, for example the aircraft is 1 minute late at the first fix, before making any corrections the pilot should again consider what might have been the cause. Has the airspeed been maintained consistently? Has there been any manoeuvring such as avoiding traffic? Has time been logged correctly? If one of these errors is identified, then the error will be a "one-off" and not cumulative. ETA for the destination can be amended to 1 minute later and noted in the Navigation Log.

If the error cannot be attributed, then it is most likely a change in the wind. This means the error will be cumulative along the remainder of the leg and timing corrections should be calculated. Again, this will be very simple and uses the proportional technique. In this case, as the aircraft is 1 minute late $1/3^{\text{rd}}$ of the way along track, it will be 2 minutes late at the second fix which is $2/3^{\text{rds}}$ of the way, and 3 minutes late at the destination. The ETA for the destination should be amended in the Navigation Log.

To summarise:

1. If late or early at a fix, determine if due to a wind change
2. If wind, amend times using the proportional technique

Flying the Route

Flying a Leg

Having explained the primary navigation techniques, this section describes how they should be applied in a practical sense.

During planning a Start Point (SP), close to the airfield, will have been selected. After becoming airborne, the pilot will head to the SP. Prior to flying overhead the SP, the pilot should widen out the turn with the aim of flying directly overhead the SP and on track, as shown in Figure 6. The time overhead can be checked, but not written down just yet as there are other tasks to accomplish first.

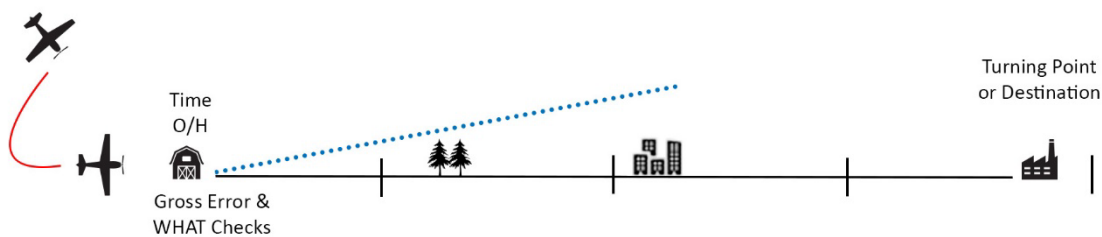


Figure 6 – Overhead the Start Point, on track

Once on heading it is vital to carry out a Gross Error Check. Use a recognisable feature, ideally straight ahead in the distance, to discount any gross error in the heading, such as steering 120° instead of 102°. The feature used, if not directly ahead, should be as close as possible to the track, and as far ahead as practical.

Once gross errors have been checked the pilot carries out a WHAT check;

- W Weather. Review the weather ahead and along track.
- H Heading. Correct heading, and D.I. aligned with compass.
- A Airspeed. As planned. Altitude suitable for the weather, and airspace.
- T Time. Now enter the time overhead the Start Point as well as the ETA for the Turning Point (or destination) in the Navigation Log. Check time for the next fix.

Having ensured there are no gross errors, and having completed the WHAT checks, there will be several minutes until reaching the first fix. The map can confidently be put away. The pilot can now concentrate on accurate flying, thorough lookout and other tasks such as a Cruise Check.

About 2 minutes prior to the first fix the map can be brought out again, and the method of TIME – MAP – GROUND used. Using time, the approximate position of the aircraft can be located on the map. Then the anticipated features can be identified on the map and verified with the features on the ground. Once the fix is identified any errors in track or time can be corrected as described previously. If there are errors in both, attend to heading correction and regaining track first, then make amendments to the ETA.

The time for the next fix is checked, the map put away again, and the pilot focusses on flying the aircraft accurately, looking out and other tasks. Perhaps a radio call, or review of arrival procedures at the destination airfield. This workflow is repeated throughout the flight, whether it's one long leg or several shorter legs. Where there are turning points, they are treated in the same way as the Start Point. The turn is widened out to ensure the aircraft passes overhead the Turning Point on track and on heading. The time overhead is checked, followed by a Gross Error Check and a WHAT Check. The time overhead the TP is now entered into the Navigation Log, as well as the ETA for the next TP or destination, and the time at the next fix is checked. Once again the map is put away, and the pilot concentrates on accurate flying, looking out and other tasks.

This workflow and method of managing workload will be successful only if the heading is maintained, time is managed and the system of putting the map away at intervals is rigorously followed.

Avoiding Weather

The dogleg in Figure 7 provides a simple procedural technique for avoiding a patch of poor weather en-route whilst ensuring that the aircraft will return to track. The aircraft is turned at a point by an amount (usually 30° , 45° or 60°) sufficient to avoid the weather. The time is noted, and this heading is maintained until the weather is cleared. The elapsed time taken flying off track is observed and the aircraft is turned back towards track, through twice the original heading change. This second heading is maintained until an equal amount of elapsed time is flown returning to track, at which point a turn back on to the original heading is made.

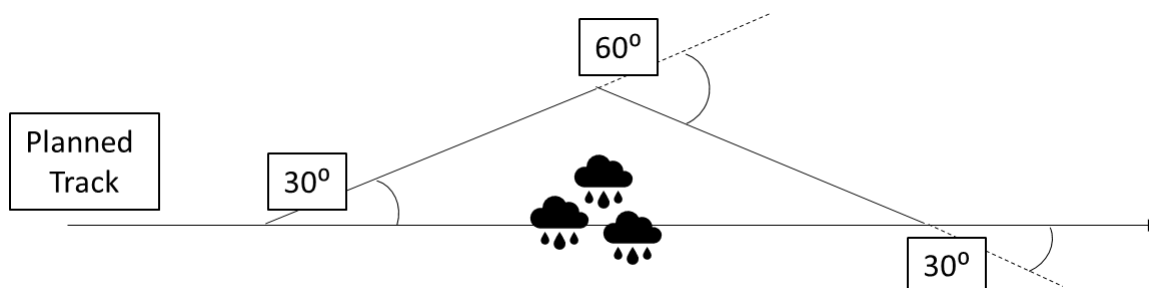


Figure 7 - Dogleg

Although track will be regained, time will be lost due to the greater distance flown. For a 30° dogleg, the time lost will be a quarter of the elapsed time taken to fly off track. For example, flying off track for 4 minutes, the ETA will be 1 minute later. For a 45° dogleg it will be about half of the time, and for a 60° dogleg it will be approximately equal to the time.

A variation on the simple dogleg technique is to turn back to a track parallel to the planned track for a period of time, as shown in Figure 8, before turning to regain track. In the example below a 45° dogleg is used.

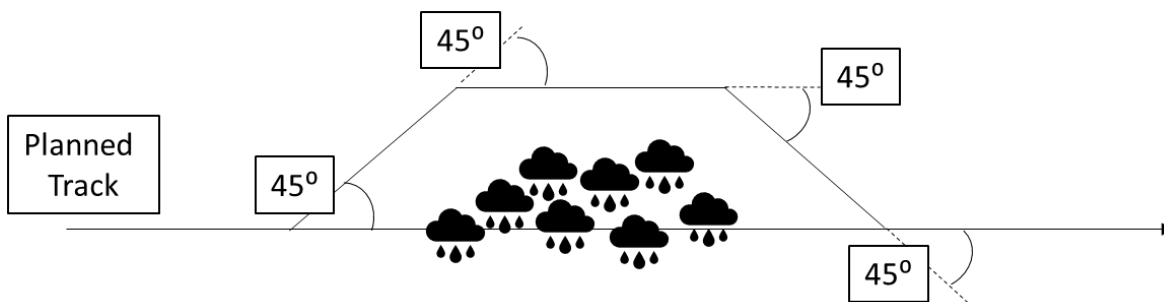


Figure 8 - Alternative Dogleg

Managing Workload

Having applied the dead reckoning techniques above, it is hopefully apparent that navigation is a logical and systematic activity, based on time. In-flight calculations and adjustments to heading and ETA are very simple, use of the map is carefully managed, and this results in increasing the pilot's capacity to accurately fly the aircraft, lookout and attend to the other important tasks. During the planning phase, periods of higher and lower activity can be identified, and the workload can be planned and distributed across the whole leg.

Departure and Arrivals

Departures

As part of a cross-country flight, a departure must be carried out and the Start Point (SP) reached. The departure method adopted will depend on the direction of the initial track relative to the runway direction.

At controlled airfields, the appropriate departure procedure published in the AIP should be chosen and followed. The Start Point should be selected at the end of this departure procedure at a VRP, or if there is no suitable VRP, then at a distinctive feature normally 3 to 4nm from the airfield.

At un-attended airfields, the pilot should depart via the circuit, and once clear either laterally by 2nm or vertically by 1500ft aal (above aerodrome level), may then fly to the Start Point. Again, the Start Point should be approximately 3 to 4nm from the airfield.

If the Start Point is on the same side of the airfield as the circuit direction (traffic side), then depart via either the upwind, crosswind or downwind leg by extending that leg to clear the circuit by 2nm, or climbing clear of the circuit by 1500ft aal, as shown in Figure 9.

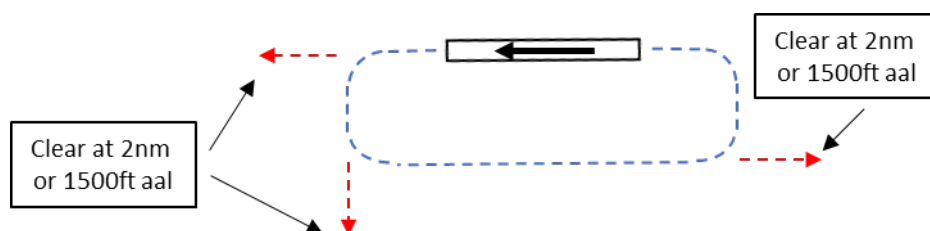


Figure 9 - Departing the Circuit (Traffic Side)

If the Start Point is on the opposite side of the circuit direction (non-traffic side) either extend the upwind till clear of the circuit (as described above) and then turn toward the Start Point. Or, climb in the circuit till clear (1500ft aal) then pass overhead the airfield and fly toward the Start Point, as shown in Figure 10.

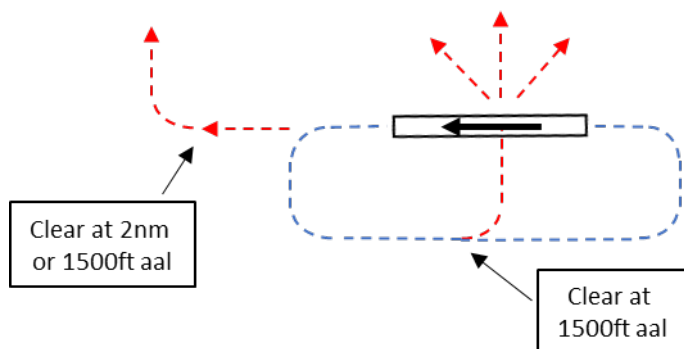


Figure 10 - Departing the Circuit (Non-Traffic Side)

All these options must take account of other traffic, with a thorough lookout being maintained, especially if choosing to depart via the overhead.

Arrivals

When planning the flight to land at another airfield, or for the final leg returning to the original airfield, plan to arrive at either a VRP or an identifiable feature 3nm to 4nm from the airfield.

Prior to arriving at this point review the AIP plate to refresh joining instructions and circuit information. If it is an airfield being visited for the first time, the arrival plate should have been closely studied on the ground during the planning phase, and simply reviewed in the air. Also, review the map to identify key features and airspace boundaries where applicable.

The important thing is not to rush an arrival. Take the time to collect ATIS if available, review and plan the arrival, and if required, obtain a clearance to enter a Control Zone. If necessary, “buy some time” by remaining well clear of the airfield or airspace, and only proceed once the joining instructions or procedures to be followed are clearly understood.

If arriving at an unattended airfield, normally plan to join the circuit via a Standard Overhead Join. However, if the runway in use and traffic can be ascertained, then you can plan to join the circuit direct onto the downwind leg, base leg or long final.

Remember, there may be non-radio traffic in the circuit, so keep a good lookout, give way and integrate into the traffic established in the circuit.

Map Reading

It has already been mentioned that dead reckoning navigation uses a calculated method, as opposed to following features depicted on the map, and that the map will be put down frequently during the flight. Nevertheless, the map is still an essential tool for planning and checking progress, as well as maintaining situational awareness. Therefore, good in-flight map reading techniques are essential.

Map reading consists of visualizing the physical features represented on the map by symbols, thus forming a mental picture of the ground by relating the features to one another (map to ground). It is also necessary to perform this analysis in reverse, i.e. seeing an arrangement of features on the ground and being able to recognise the relevant portion of the map (ground to map). Effective map reading requires much practise but there are several factors which can make the task easier. The most important of these are thorough flight planning and pre-flight route study.

Fixes

When in flight, maintaining track and time should be a prime aim. Errors should be recognised and acted upon early, but concentration on navigation to the detriment of other tasks must be resisted. It is equally important to keep a good lookout to reduce the risk of collision, to be aware of any potential weather problems, and to manage the aircraft systems. To this end, significant features should be selected for use as fixes at the planning stage, at 6 to 8-minute intervals. Fixes need not be exactly on track, a good feature close to track will usually be better than a poor feature on track. The ideal fix will have the following properties:

- **Big.** The check feature should be big or be part of a big feature. However, it must not be so big that a precise point is indistinguishable.
- **Unambiguous.** The feature must be selected to ensure that it cannot be confused with a similar feature nearby.
- **Vertical Extent.** A feature such as a hilltop, mast or chimney may well be visible from several miles away.
- **Easily Identified.** The check feature should be seen and identified easily, to minimize time spent searching for it.

Only rarely will a feature possess all these attributes and some compromise will be necessary.

Choice of Fixes

Some of the ground features suitable for visual map reading are discussed below. However, only rarely is any one feature used in isolation; it is the relationship of one feature to another that provides confident identification:

- **Coastlines.** Coastlines generally offer an excellent opportunity for fixing. There is usually some associated feature such as a river estuary, headland, or inlet to enable position to be fixed with reasonable accuracy.
- **Water Features.** Large rivers, estuaries, and lakes normally show up well. However, they naturally tend to occupy the lowest ground in the area and so may be hidden from view by the surrounding terrain. This is particularly true of lakes in mountainous regions; it is quite possible to fly within a mile or two of a mountain lake and not see it. Smaller rivers are often tree-lined; the trees can assist in locating the line of the river but can also tend to hide the detail so that particular features of the river may not be seen.

- **Mountains and Hills.** As height above the ground decreases, the terrain contours take on considerably more significance. However, the interpretation of topography for mountains and hills from the map is more difficult than the interpretation of water and man-made features. Isolated and prominent hills provide the best opportunity for fixes. Terrain which undulates uniformly is extremely difficult to use unless there are additional features such as significant woods or transmission masts. Wherever there are mountains and hills there will be valleys, and these can be extremely valuable features. They can usually be identified with confidence from their orientation and from the presence of roads, railways and settlements, and they provide a line feature for navigation and a route away from the highest ground.
- **Masts.** Masts, with their vertical extent, can provide good visual clues to position at lower altitudes. However, they should not be selected as turning points, as they are difficult to see in poor visibility.
- **Towns and Villages.** The identification of a town or village must normally be done by relating it to other features in the vicinity, e.g. roads, railways, rivers and hills.
- **Railways.** In areas of dense population and industry, the identification of railway lines can sometimes prove difficult. However, in more rural areas they provide an excellent line feature and, if there is some unique aspect to the line such as a junction, station, or conspicuous bridge, a pinpoint can be obtained.
- **Roads.** The usefulness of roads as check features is extremely variable, depending on the nature of the surrounding landscape. Motorways can be particularly distinctive especially if viewed lengthways. By comparison, a single-track, narrow road might prove extremely significant in open country, especially over barren mountainous terrain. In general, the larger the road the more useful it is likely to be.
- **Woods.** Like roads, woods can vary between excellent and useless. Although there can be some change to wood shapes due to felling and de-forestation, the impact of this activity is normally obvious. Nevertheless, some care is needed.
- **Miscellaneous Features.** Many other features can prove to be satisfactory navigation checks. Power transmission lines can act as line features and, can provide pinpoints where they cross each other or other line features. Power stations, airfields, transmission masts, and lighthouses, are all worthy of consideration.

Using the map when airborne

Aeronautical maps are quite large and need to be properly folded prior to flight. When holding the map, make sure it is orientated track up, or at least in the direction you are flying. This will enable an easier orientation to the features around the aircraft. If using a digital map, select the “Track Up” function.

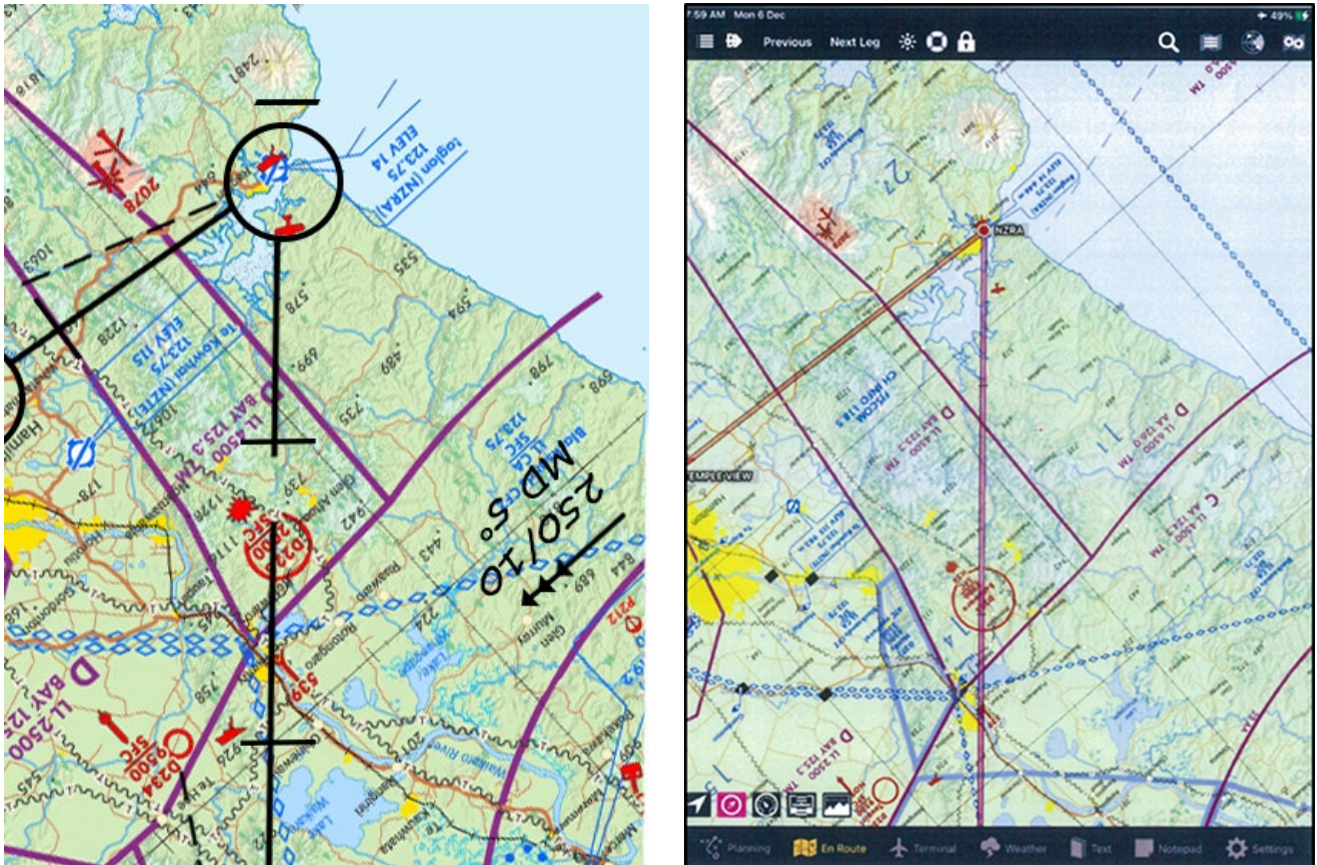


Figure 11 – Hold the map “Track Up” – NOT TO BE USED FOR NAVIGATIONAL PURPOSES

Also, try to hold the map up near the instrument panel, when referring to it. This prevents the pilot from looking down too much, and peripheral vision outside of the aircraft is maintained.

When identifying features on the ground, start by identifying the large features first, then move into the smaller features next. The presence of features that lead towards the check feature can be used to draw the eyes to the area. A lead-in is essential for small check features. Look for distinguishing features, that are particular to the feature you are identifying.

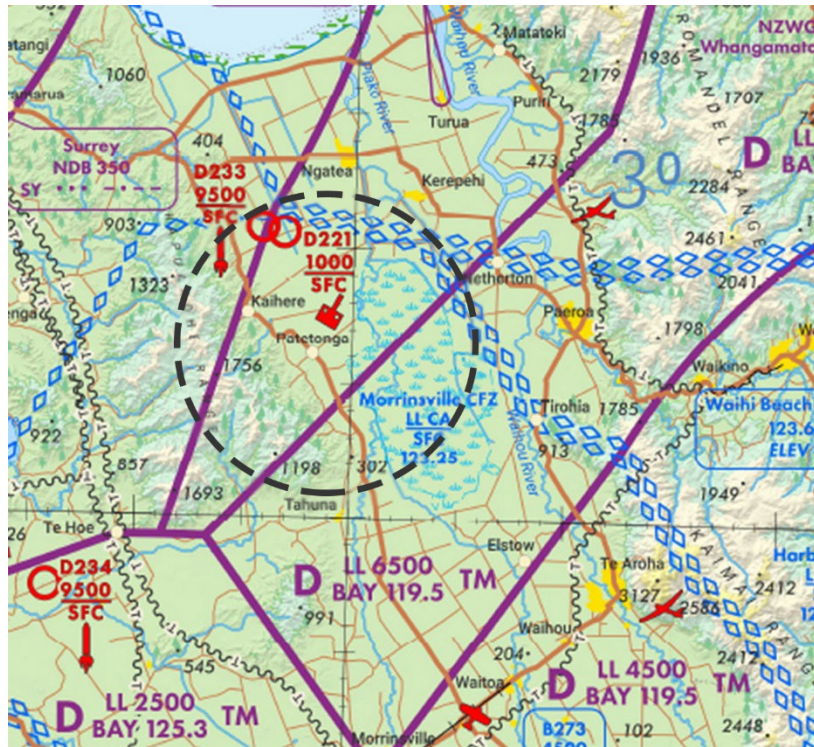


Figure 12 - Feature Identification – NOT TO BE USED FOR NAVIGATIONAL PURPOSES

For example, identifying Patetonga in Figure 10:

- Large to small. There are ranges out to the East and West.
- Lead in. If flying northwards, there is a main road that runs from the south east, to the north west toward the village.
- Distinguishing features. There is a swamp to the East with an inward curve. The main road runs through the village and there is a perpendicular crossroads. Further north west along the main road is a distinctive “S” bend.

Diversions

Diversions can arise for many reasons, but the most likely cause is un-forecast poor weather conditions. As such, timely decision making is needed, followed by re-planning and flying to an alternative airfield. Suitable alternative airfields will have been considered during the pre-flight planning.

Before looking at an example of a diversion, there are two more airborne techniques which will need explaining. Similar to the previous techniques, they are designed to minimise the use of navigation equipment and complex calculations whilst airborne, allowing the pilot to maintain overall management of the flight.

Estimating Track

If a straight line were to be drawn on the map, it’s angle can be visually estimated quite accurately. By referring to the 90° angle between the lines of longitude and latitude, depicted on the map, the angle of the track line can be estimated as can be seen in Figure 13.

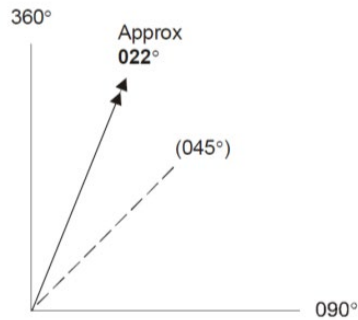


Figure 13 - Visualising Track

With some practise (this can be practised on the ground) the degrees True of a track drawn on the map can be easily assessed. Applying variation gives degrees Magnetic track, and then all that remains to establish the heading is to calculate the effect of the wind.

Calculating Drift and Head/Tail Wind

Before becoming airborne the wind and maximum drift for the flight were written onto the map, pictorially in degrees True, and numerically in degrees Magnetic. The pictorial representation of the wind is there to help visualise it's effect, and avoid applying drift in the wrong direction.

There are several methods for calculating the drift and head or tail wind for a given heading. In this guide only one technique is described, that of visualising the effect of the wind on the DI/HSI or an unused navaid. In Figure 14, an example is shown where the aircraft is on a heading of 230° flying at a TAS of 120kts, and the wind is 260/20. Firstly visualise a vertical line running centrally through the DI face (vertical orange dashed line). This represents a scale of wind speed, the maximum for this wind being 20kts. Then visualise a horizontal line running centrally through the DI face (horizontal orange dashed line). This represents a drift scale, the maximum drift being 10° having been previously calculated and anoted on the map. Visualise the wind on 260° touching the outer edge of the DI, as that represents the maximum wind speed.

Now, imagining a line drawn horizontally from the tail of the wind vector to the wind speed scale (horizontal green dashed line), "read off" the proportion of the wind scale. In this case it is $\frac{3}{4}$. Therefore the head wind on this heading, will be 15kts ($\frac{3}{4}$ of 20kts). Then imagine another line drawn vertically from the tail of the wind vector to the drift scale (vertical green dashed line), and again "read off" the proportion of drift. In this case it is $\frac{1}{2}$. Therefore the drift on this heading is 5° to the right, and a heading of 235° would be selected to maintain the track.

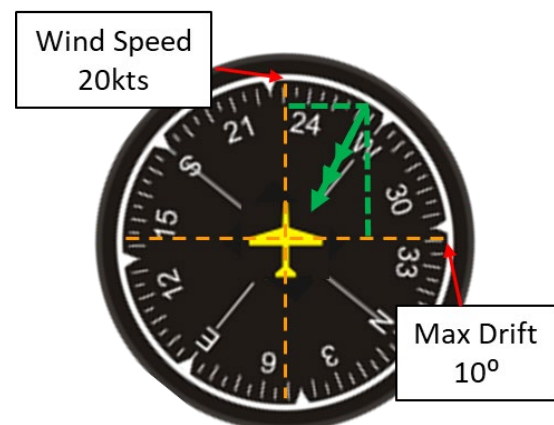


Figure 14 - Calculating the Effect of Wind

Diversion Planning

Once the decision has been made to divert to an alternative airfield, a Start Point must be chosen. This could be a convenient ground feature on track a few miles ahead of the current position. Or, if there are no useful ground features, the Start Point can be located using the 6-minute markers, usually a few minutes ahead of the current time. Circle the Start Point as well as the new destination on the map, then freehand a line between the two, as shown in Figure 15. It does not have to be perfectly straight.

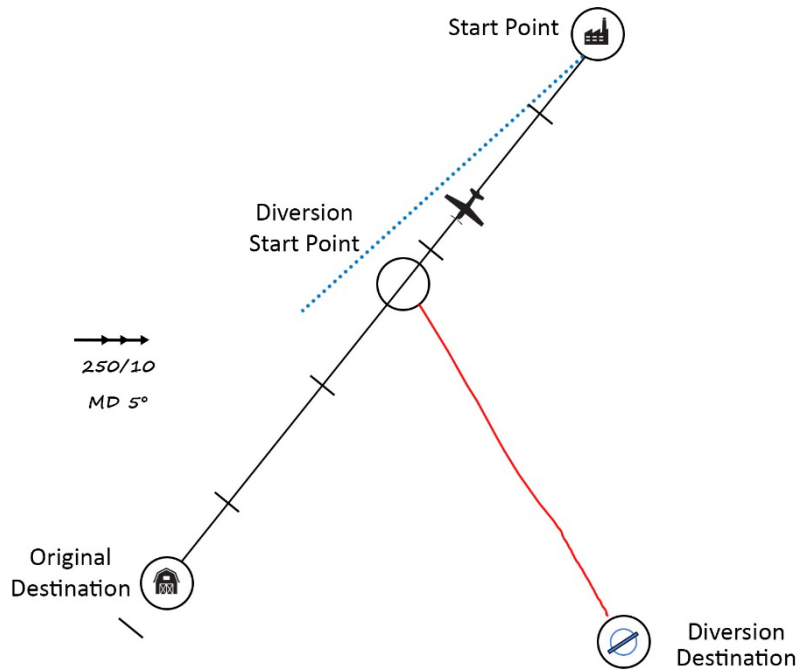


Figure 15 - Diversion Planning

Then estimate the True Track using the method already described. The True track in Figure 15 is approximately 150° . With variation of 20° East, the Magnetic Track is 130° . With the desired track obtained, wind can be applied to obtain the heading as well as the groundspeed.

With an initial heading of 130° , a TAS of 120kts, visualise the wind of $250^\circ/10$ kts, as in Figure 16

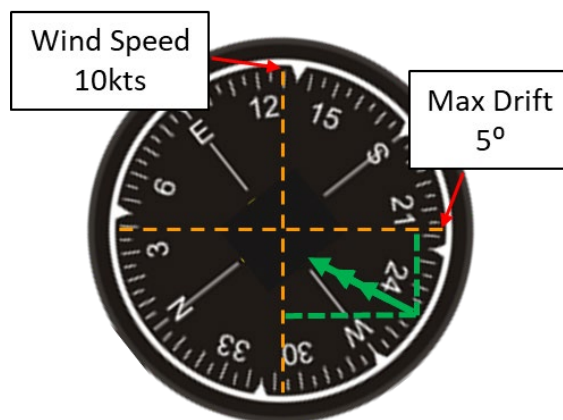


Figure 16 - Visualising the Effect of Wind

The drift will be $\frac{3}{4}$ of the maximum drift (5°) resulting in approximately 4° to the right, and a required heading of 134° . The tail wind is $\frac{1}{2}$ of the wind speed (10kts) resulting in 5kts. If TAS is 120kts, then groundspeed is 125kts, and the aircraft will travel approximately 12nm every 6 minutes (Groundspeed / 10). Now 6-minute markers can be drawn on to the diversion leg as seen in Figure 17.

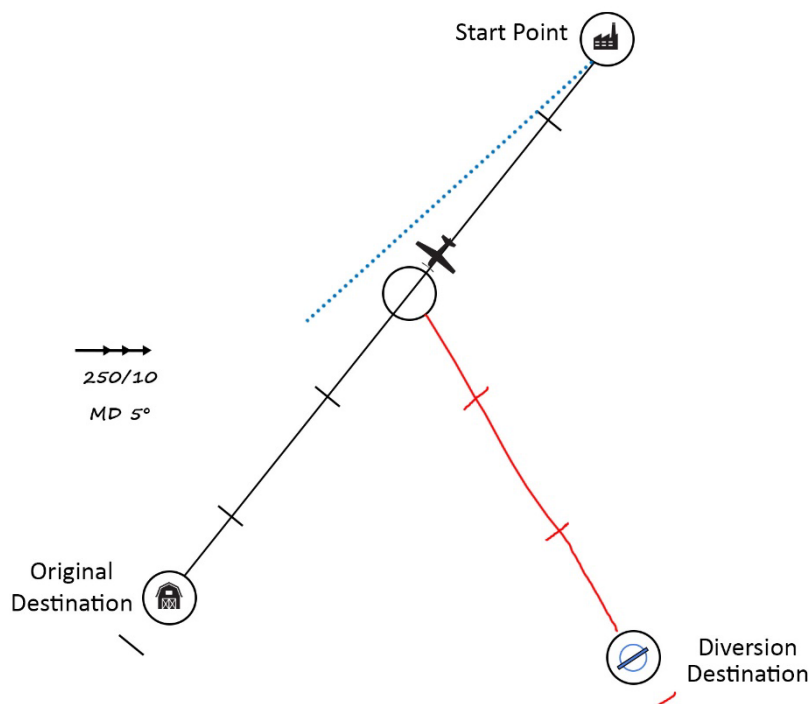


Figure 17 - Diversion Timing

It can now be seen from Figure 17, that the elapsed time to the diversion destination will be 16 minutes after the Start Point. Convenient fixes can be chosen to check tracking, and the elapsed time to the fixes read off the time scale.

So, to summarise, there are 6 steps;

1. Freehand desired track
2. Estimate True track
3. Convert to Magnetic track
4. Calculate drift and Heading
5. Calculate groundspeed and draw in 6-minute markers
6. Note elapsed time to destination and choose fixes

With practise this will only take a few minutes, and this procedure can be practised easily on the ground.

With the essential planning complete, use the same techniques as described earlier to fly the new route. Plan to fly overhead the SP on track, noting the time. Carry out a gross error check followed by a WHAT check. Calculate ETA for the diversion destination, check the time at the next fix and put the map away. Concentrate on accurate flying, looking out and other tasks such as fuel calculations or reviewing arrival procedures for the new destination. A couple of minutes before arriving at the fix, bring out the map, use TIME – MAP- GROUND to identify the fix and check tracking and timing. Make any required adjustments, check time for the next fix and put the map away again. And so on.

If time is short, it is perfectly acceptable to turn onto track at the SP using the magnetic track for an initial heading, and then calculate the drift for a more accurate heading once on the new track.

Lost Procedure

Thorough planning and careful route study should drastically reduce the possibility of becoming lost. Often the pilot may have a “sense” of being lost, when actually they are merely uncertain of their position. This can usually be remedied by using the TIME-MAP-GROUND technique. Of course, this is reliant on the heading having been maintained.

Among the most common causes of uncertainty are missing a turning point and flying on regardless or having to re-route to avoid bad weather. Checking for gross errors in heading and timing may resolve the problem, but should uncertainty persist, it is important to recognise the problem as early as possible and take positive remedial action.

Initial Actions

Maintain the heading until a visual feature is seen. Then, noting the time, hold overhead the feature and try to identify it by comparing it to the map. It is essential not to start wandering around. If no visual feature can be seen, then maintain the heading. If possible, climb to increase the area of view and then fix position by the best available means; visually, GNSS or with assistance from ATC. Many pilots hesitate in seeking ATC assistance because of embarrassment, concerns over paperwork or fear of retribution. These concerns must be put to one side as they will inhibit good decision making, and probably make things worse. If having difficulty in contacting ATC, squawk 7700, and try 121.5mhz, as overflying airliners are often maintaining a listening watch and can assist in relaying messages. If carrying a mobile phone, try calling the applicable ATC unit. It’s a good idea to have saved these numbers onto your phone.

Subsequent Actions

Should these first actions fail to resolve the issue then it is important to stay calm, keep holding overhead the feature or maintaining heading, and keep track of time. An assessment of fuel remaining should be made. It should be possible to estimate the approximate position based on the position of the last known fix, the heading flown subsequently and the elapsed time.

If the heading has been maintained, a DR position can be established. Which is another reason why holding the heading is so important. With consideration of the wind, the heading will approximate the Magnetic track. Convert this to True track by adding the variation and then freehand this track from the last known position onto the map as shown in Figure 18. Note the time elapsed since the last known position and count the time off in 6-minute steps (using the distance of previous 6-minute markers will be sufficiently accurate). This establishes a DR position and a circle of uncertainty can be drawn around it. A sensible radius for the circle of uncertainty might be equal to 10% of the distance flown since the last fix.

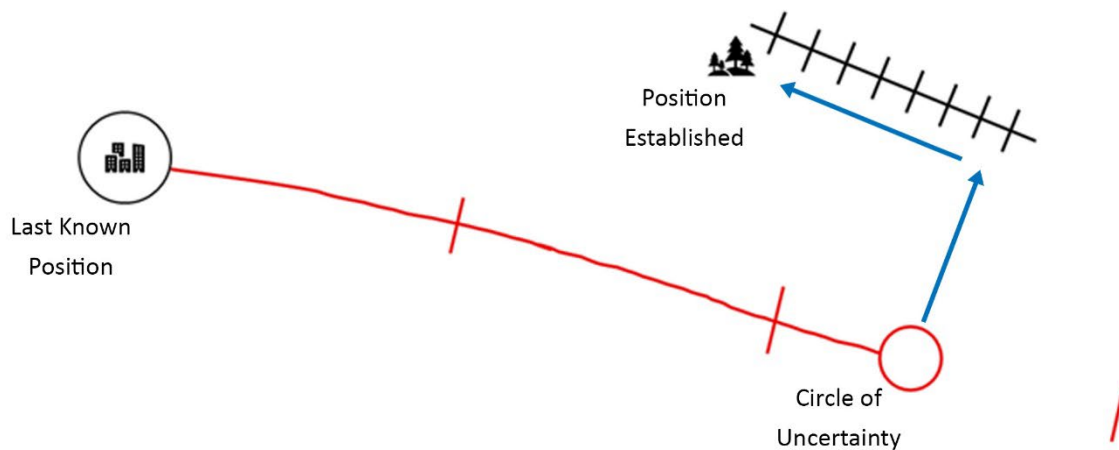


Figure 18 - Lost Procedure

Maintain visual contact with the ground and set heading towards a line feature (e.g. coastline, railway, major road) outside of the circle of uncertainty, whilst map reading from ground to map. On reaching the line feature, it can be followed until a further feature allows the actual position to be established.

Inadvertent Entry to IMC

This section discusses practical measures if inadvertently encountering Instrument Meteorological Conditions (IMC) during a VFR flight. It assumes a pilot who does not hold an Instrument Rating or is un-current or un-prepared for IFR flight, and an aircraft fitted for basic instrument flight (AI, ASI, ALT, DI, and VSI). It is intended to help pilots keep their aircraft under adequate control until suitable visual references are regained.

Essentially it is a situation where good Threat and Error Management (TEM) becomes very important. Ideally the situation should be avoided altogether but if not, a progressive consideration of threats will need to be considered and managed.

Avoiding IMC

During the pre-flight planning the general area weather conditions must be checked and assessed as suitable for a VFR flight, with a low risk of significant deterioration of conditions. The cloud base should be considered, and a cruise altitude planned to give generous terrain clearance and at the very least, comply with regulations.

Both an MSA and a “Minimum VFR Altitude to Continue” as already described, should be calculated for each leg and noted on the Navigation Log. If arriving at the “Minimum VFR Altitude to Continue” un-expectedly, it serves as a cue to the pilot to take action.

Diversion options should have been considered at the planning stage, and when intending to fly across higher ground it is useful to have identified “escape route” options to lower ground.

Recognition of Inadvertent Entry to IMC

When airborne, a deterioration in the weather can be quite subtle, and may go un-noticed until becoming significant.

Pilots should assume they are in IMC conditions anytime they are unable to maintain aircraft attitude control by sole reference to the external cues, regardless of the circumstances or the prevailing weather conditions. In addition, a pilot should accept that they are effectively in IMC anytime they

are unable to navigate or establish geographical position by visual reference to landmarks on the surface which may be obscured by cloud. Such situations must be accepted by the pilot as a genuine emergency, requiring immediate action.

Whilst the priority is to leave IMC as quickly as possible, a panicked “knee jerk” reaction must be resisted, such as a steep turn where the possibility of losing control becomes very real. Movement of the body and particularly the head, need to be kept to a minimum to avoid the onset of illusions and spatial disorientation.

Maintaining Control

Once the pilot recognises that they have entered IMC, they should understand that the only way to control the aircraft safely is by using and trusting the flight instruments. The pilot should make a firm decision to change from visual reference to instrument flight before visual references are completely lost. The pilot should deliberately remain calm and initially concentrate on the attitude indicator, selecting and maintaining the correct attitude for straight and level flight whilst trimming accurately to ease workload. They can then build up to a full instrument scan.

The altitude now needs to be checked against the MSA for that leg. During planning an MSA was calculated by searching for the highest obstacle 5nm either side of the track, including 5nm beyond the Turning Points or Destination, rounding the altitude of the obstacle up to the nearest 100ft, and then adding 1000ft, or 2000ft if over mountainous terrain. If below MSA, climb immediately to that altitude. If above MSA, then descend to that altitude (which may result in returning to VMC). Of course, this MSA only works if the aircraft has remained on-track. If off-track then the MEF can be read from the map, adding 1000ft or 2000ft respectively. This becomes the MSA and the aircraft must be flown at this altitude as a minimum whilst in IMC.

Having established a safe altitude, the next step is to consider ice protection. In most light single-engine aircraft this may be limited to selecting the pitot heat on and selecting the carburettor heat to “Hot” from time to time to check for induction icing.

Exiting IMC

In most cases, an inadvertent entry into IMC will be best resolved by a 180° turn to fly back into visual meteorological conditions (VMC). This manoeuvre needs to be planned before attempting to execute the turn.

Firstly, the direction of turn should be considered taking into account factors such as terrain on each side of the flight path. For example, if before entry into IMC the pilot was aware of terrain to the left of track then a turn to the right might be the best plan. Whilst the 180° is the simplest exit strategy it is quite possible that the aircraft had just passed over higher ground and is heading toward lowering terrain. In this case a 180° turn would not be appropriate (see below for further actions).

Before entering the turn, the pilot must decide on a target heading to roll out on. This can be achieved by rotating the heading bug to the bottom of the DI/HSI. Where there is no heading bug, the pilot should note the heading indicated at the bottom of the DI/HSI – this can be noted down, or a suitable Navigation Aid can be set with the desired heading at the top of the indicator. A rate one turn should be used for the manoeuvre.

Once straight and level on the planned heading to exit, it may take a few minutes to get back to VMC. A period of time will have elapsed before the pilot recognised that entry into IMC had occurred and

further time will have been utilised establishing straight and level flight, and yet more time taken to plan the escape turn.

Further Action

If the 180° turn fails to achieve a return to VMC then the pilot will need to remain calm and accept that they will have to continue to fly the aircraft by sole reference to the instruments, and further action will need to be taken.

If still in IMC, then the pilot should ensure the aircraft is in stable straight and level flight, and properly trimmed. Then make a “Distress” call on the most suitable frequency and squawk 7700. This should be an ATC unit (either “radar”, “FISCOM”, or a Tower). If unable to raise an ATC unit, try 121.5, as overflying airliners are usually listening out. Do not hesitate to make this call because of embarrassment, or a sense of failure, or a concern about retribution. The call could be a real “life-saver”. ATC may be able to offer assistance and advice to help find VMC and a potential diversion airfield.

If unable to contact anyone using the radio, the pilot should try their mobile phone. It’s a good idea to have stored the appropriate numbers in the phone. However, the primary task of maintaining control through instrument flying remains the priority and the task of using the phone, broken down into small steps.

If all attempts at contact fail, then the pilot will need to come up with another plan. Consider the bigger picture of the weather situation. Where is the weather better, or in which direction is it forecast to improve? In which direction is there lowering terrain? The combination of these should help in deciding on an appropriate heading to reach VMC. Equally, a heading to fly out over the sea may be best, as this will reduce the MSA to its absolute minimum.

Finally, if all of this fails don’t give up. Review fuel endurance remaining and keep going for as long as fuel remains. If fuel runs out prepare for a forced landing, by trimming for the glide, turning into the wind and then keeping the wings level. It is possible the aircraft breaks cloud low to the ground, and some manoeuvring may be needed to complete a landing.

Night Navigation

This section discusses the aspects of navigation at night. There are other differences associated with night flying, but these are well described in other publications and not repeated here.

The principles of navigation at night are essentially the same as for those used during the day. However, due to the difficulty of recognising physical ground features, the DR techniques already described are particularly relevant. Problems associated with judging distance are more easily overcome with reference to the time markers on the map, using;

TIME – MAP – GROUND

Planning

Visual navigation at night requires particular attention to the flight planning, with consideration of some important differences when compared to navigating by day.

During night flight a deterioration in weather can be particularly difficult to detect. It is therefore vital to have a good appreciation of the prevailing weather conditions and forecasts and take a

conservative approach as to what is acceptable. Conditions that may be accepted by day, may not be acceptable for night flight.

Alternative plans and alternate airfields must be considered carefully as many airfields will not be available at night, limiting options if a diversion is needed.

In the case of operating a single engine aircraft at night, the route over which the aircraft will fly should favour flatter, “friendlier” terrain, to enable a greater chance of success in the event of a forced landing.

Ground features for fixes and turning points should be selected for the ability to identify them at night.

ATC units selected may be different from those selected by day for a similar route, as many units will be “off watch”.

Similar to planning a flight by day, both an MSA and a “Minimum VFR Altitude to Continue” as already described, should be calculated for each leg and noted on the Navigation Log. As terrain is difficult or impossible to see at night, the MSA for each leg should also be the minimum cruise altitude.

Map Reading

Map reading becomes more challenging at night. As stated, terrain is virtually impossible to see, and the ability to see other ground features will depend on the time of night and amount of residual light or moonlight available. Also, the map is colour coded and when using red light at night, many of those colours are not visible. It may be a good idea to carry an extra torch with a dim white light for looking at the map, or to mark the outline of key features with a dark coloured pen.

Cities and towns can be identified by their shape which is depicted on the map. However, small settlements and villages are represented by a small circle on the map and may not be easily identifiable.

Generally, only main roads with street lighting are visible at night. However, during busy periods such as “rush hour” with large amounts of traffic, other roads may become visible. But only for that period.

If it is a clear night and the moon is present, bodies of water such as lakes, ponds and rivers become very visible. With no moon, they may be virtually invisible.

Airborne

As for navigating by day, navigating by night requires a managed division of tasks, so that other essential items for the flight are attended to at the right time. Again, DR techniques, and particularly the management of time, assists greatly in managing workload and ensuring a lookout is maintained as well as good situational awareness.

Weather changes can be particularly difficult to detect, but there are some helpful cues to alert the pilot to the proximity of poor weather. Losing sight of the stars, may be due to flying under cloud. If a glowing “halo” appears around the navigation lights (red and green), you are likely to be flying at the cloud base. If ground lights begin to look hazy, you may be flying into a layer of cloud or over fog. Even though the visibility appears fine, you may be flying through precipitation. Sparkles illuminated by your strobes indicate precipitation such as rain or snow showers.

Any of these cues require immediate action to avoid an inadvertent entry into IMC.

If at any time during the flight, problems such as worsening weather, disorientation or with the aircraft occur, do not delay in seeking assistance from ATC.

Using GNSS

This section discusses the use of GNSS as an aid to visual navigation. It refers to properly installed GNSS units as part of the aircraft avionics and not hand-held devices such as phones or tablets.

GNSS as an “Aid”

The term “aid” is important as it can be tempting to think GNSS navigation replaces many of the foundational navigation techniques described earlier in this text. However, this view is in error as all of the techniques and disciplines required of DR navigation are still highly relevant to ensure a structured approach to navigation, even when using technology.

The Challenges

The important point being that GNSS is a very useful aid when used in the right way. If used in the wrong way, GNSS will present many challenges. For instance:

- Breakdown in Situational Awareness. When used correctly to supplement visual navigation, GNSS can enhance Situational Awareness. However, when GNSS is relied upon excessively, complacency and a lack of pre-flight planning can occur which leads to a reduced level of Situational Awareness, and in flight further breakdowns can occur due to too much time spent “head down”.
- Data Programming. Manual data input without verification may produce wildly inaccurate navigation, which may remain undetected until an infringement of controlled airspace occurs. Programming and data input while airborne, increases the chances of an error and again necessitates “head down” time.
- Use of the “DIRECT TO” Function. Using this function can lead to a direct routing infringing controlled airspace, a danger area, or a routing over un-suitable terrain.
- Poor Database Accuracy. Poor database accuracy may be due to incorrect depiction, the absence of some controlled airspace boundaries, or out-of-date information.
- Lookout. Any re-programming of the GNSS will require considerable “head down” time, significantly reducing the ability to “see and avoid”.
- Excessive reliance on GNSS. Large navigational errors can arise when GNSS is used as the sole navigation method, where gross error checks are not carried out, or there is no Navigation Log to verify the GNSS output.
- Pressing on in Bad Weather. Because of the known accuracy of GNSS, there is a tendency for pilots to “press on” in adverse weather where previously, they would have turned back or diverted. Some pilots also plan to fly very close to controlled airspace boundaries in the belief that GNSS will deliver exceptional accuracy.

Successful GNSS Usage

Having said all of that, when integrated properly into a structured navigation methodology, GNSS can be a very valuable aid.

Pre-flight planning and preparation must still be thorough and include marking the map with the route, fixes and time markers. A Navigation Log should be prepared in the same way as previously described. A thorough study of the chart should take place to identify airspace boundaries, VRPs, fixes, turning points, and visualising how these will appear when airborne. Also, options need to be considered in case of encountering weather en-route, or the need to divert to an alternate airfield.

When airborne, GNSS should only be used to supplement the navigation. The use of the map, WHAT checks, gross error checks, time management should all be utilised. These are all “flight management” techniques, with GNSS providing a supplementary source of information to add confidence and efficiency.

Pilots need to be familiar with the GNSS unit fitted to the aircraft to avoid time wasted, input errors, distraction and “head down” time during flight.

The workflow patterns based on time and described earlier should be used to manage workload, ensure that a good lookout and situational awareness is maintained and to organise priorities.

Up-to-date maps and charts must still be carried in the aircraft and used with visual navigation techniques as the primary means of navigation and verifying airspace.

Programming should be completed on the ground, and re-programming in the air kept to an absolute minimum.

Following a deviation from track, care must be taken if using the “Go To” function to ensure that the new track does not infringe airspace. A return to track as previously described would be a preferable course of action.

Maintain database currency by purchasing updates from the manufacturer.

When re-routing or diverting, use the diversion techniques described earlier for estimating track and heading to get the diversion safely started. Catch up with GNSS programming as time allows and keep the programming as simple as possible.

Conclusion

This completes the *Practical Flying Guide 1 - Visual Navigation*.

We have discussed the importance of thorough pre-flight planning, as well as studying the route and visualising how ground features will appear from the air. Dead reckoning navigation techniques have been explained with emphasis on the time-based nature of navigating. This time-based structure provides a managed approach to the cross-country flight, ensuring tasks are properly prioritised and distributed over the time available, allowing for a thorough lookout and situational awareness to be maintained. Strategies have been suggested for dealing with situations where the flight has not gone to plan, either due to deteriorating weather or becoming lost. And we’ve discussed some of the differences to consider when navigating at night or using GNSS as an aid to navigation.

It is hoped that the techniques described, along with the workload management methods will go a long way in providing pilots with the tools needed for safe and enjoyable cross-country flying.

