

Instrument Flying Training Notes—(supporting a one day course)

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1 Course Objectives

The course is designed to give sailplane pilots the basic skills and knowledge that will get him/her out of trouble if caught in or above cloud. On completion of the one day course pilots should understand how to:-

- a. Navigate above cloud (and in cloud if necessary).
- b. Fly with a partial panel. (i.e Turn and Slip but not Attitude Indicator)
- c. Plan and execute an approach

2 Learning process

2a Knowledge and Understanding

Before embarking on this training it is important to realise that it is similar to learning to fly all over again. Learning any new skill takes time, and there are usually unknown depths to the subject, cloud flying is no exception. For this reason you should study these notes before the course, and there will be a test, ground school and a comprehensive briefing before the airborne practice.

2b Flight Skills

You will be shown how to fly without any external visual references. During this process you will learn that accurate and smooth flying, and trusting your instruments is the key. Using instruments well, demands a thorough understanding of what they are telling you, you will also learn how to use this knowledge to recover from an unusual attitude.

2c Navigation Skills

Navigating either above or in the clouds not only calls for greater situational awareness, but you will also need to know how to position yourself for a safe descent through cloud. You will be shown how to achieve this.

3 The Human body

The human body did not evolve for flight. When flying we are in an alien environment, and our senses become confused. Studies suggest that an “untrained” pilot flying in cloud will become disorientated in less than 60seconds. This is called spatial disorientation.

3a Sense of balance

We have 3 sensory systems for orientation;

- a. Visual, through our eyes.
- b. Motion sensing through the inner ears.
- c. Proprioceptive, through sensation on our skin, muscle and joints.

Our eyes are the reliable sense we use to confirm which way is up, but when flying in cloud we have no visual references. However we can walk in the dark and this is by using the receptors in the inner ear and proprioception. Swimming in the dark is more difficult because we then rely solely on the inner ear. In flight, gravity sensing is unreliable because of turning and acceleration.

Our ability to sense our position through nerves in skin and muscle. You will sometimes hear pilots talking about flying by the seat of their pants, very romantic but impractical except sometimes in thermal detection. It does not matter how much of the “right stuff” you have, in terms of spatial orientation the body is not able to tell you the truth.

We must learn to interpret the instruments and rely on them, they are our only trustworthy indicators.

3b the leans

The inner ear is able to detect changes in direction, provided the change is greater than 3° per second. Changes below this rate will go unnoticed.

If flying straight and level, but unrecognised by you the aircraft slowly banks to the left at 2° per second. After 15 seconds you have 30° of bank, and you notice the turn indicator is deflected. You roll the wings level, and your inner ear detects a roll to the right. You will now ‘remember’ that you are leaning to the right, despite the instrument indications. This is called the “leans”, and must be ignored by the pilot.

4 Instruments

4a Turn and Slip

The turn and slip indicator is a gyro instrument with a curved level at the base. If the heading changes, the instrument will indicate a turn (IT MEASURES YAW AND DOES NOT DIRECTLY INDICATE BANK ANGLE). Try this on the ground before take off.

TURN & SLIP INDICATES YAW, NOT BANK ANGLE

		 <div style="border: 1px solid black; padding: 2px; display: inline-block; margin-left: 10px;">Ball in centre</div>
Aircraft yawed to the right.	Aircraft in an under-ruddered right turn	Balanced right turn.

The slip ball is a command instrument----Just kick the ball back into the centre.

By yawing the aircraft the heading changes and the instrument will indicate a turn. To make an inference about bank, the controls must be co-ordinated (BALL IN THE MIDDLE).

It follows that if the needle is deflected, and the slip ball is in the middle, the aircraft is banked and turning.

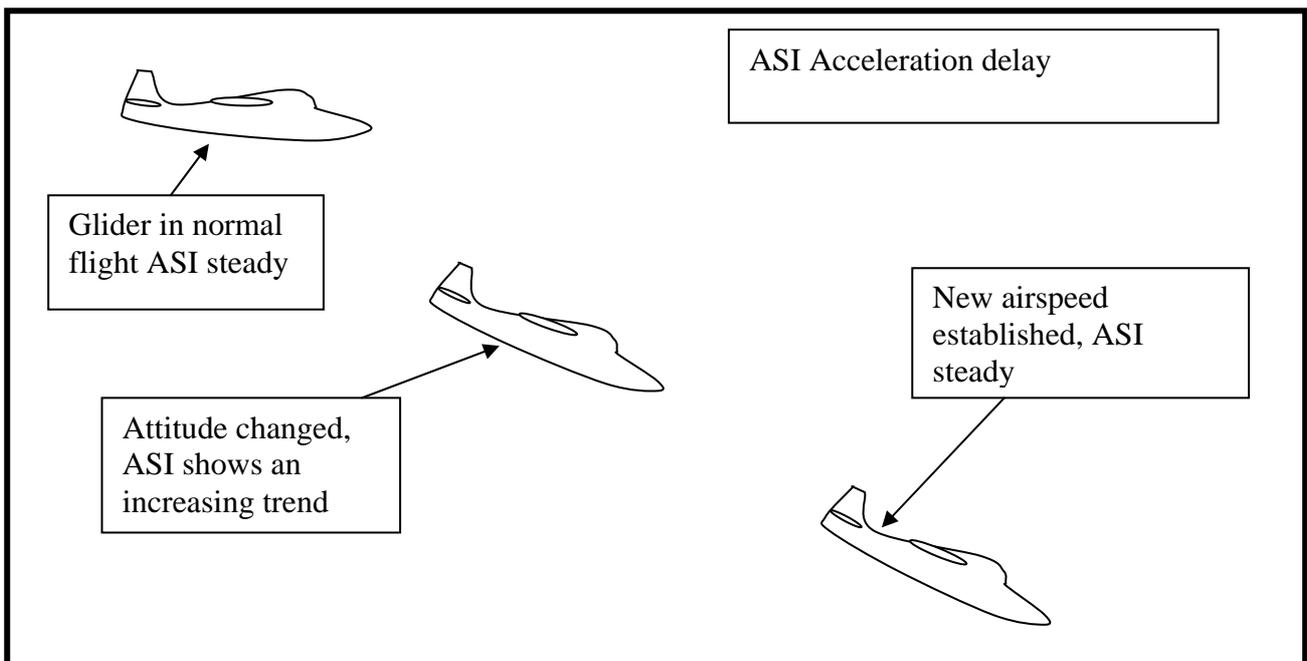
In powered aircraft the instrument is calibrated to give a rate one turn (3° per second) when the needle is on the first mark. To avoid over reading, glider instruments are modified to a rate of 12-14 $^\circ$ per second with the same indication. This calibration should be remembered because we are able to “time” heading changes and this will be discussed later.

Other instruments are commonly seen;-

1. Attitude Indicator(AI)---The AI or artificial horizon, provides direct pitch and roll information. Bank angles can be read directly from the instrument, pitch is usually geared. The use of the AI is not included within this course.
2. Turn-co-ordinator----The turn co-ordinator displays a small stylised aircraft on the dial. While being a similar rate gyro, unlike the turn and slip indicator, the indicator is angled to the horizontal, and some bank information can be inferred. The use of this instrument has limitations which are beyond the scope of the course.
3. The variometer can be useful to confirm the ASI readings, but it also indicates external air movements.

4b Airspeed Indicator

When flying visually, the airspeed indicator (ASI) is used to confirm our pitch attitude is correct. There is always a delay between changing pitch attitude and the new speed appearing on the ASI. The delay occurs because time is required for the aircraft to accelerate (or decelerate) to the new value. When in cloud we are unable to observe our pitch attitude directly, and this means the instrument must be interpreted in a special manner.

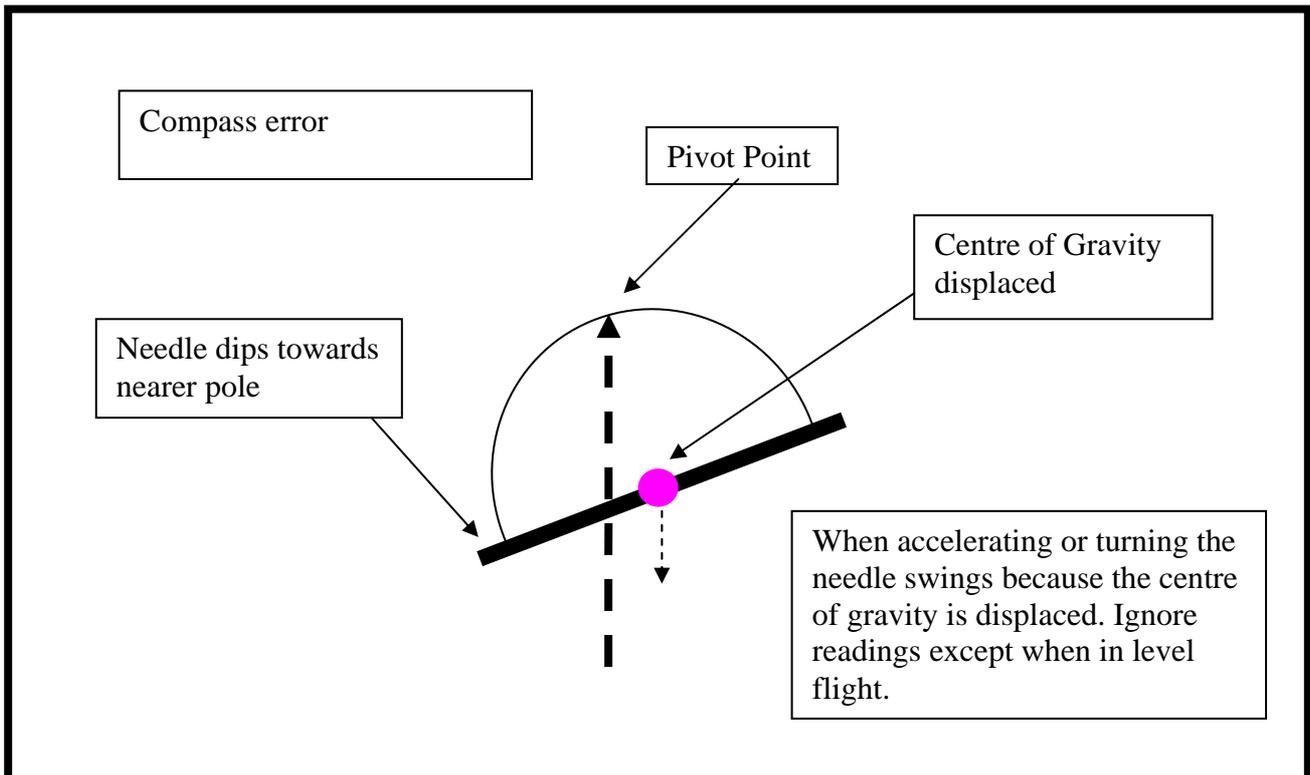


The ASI will misread if there is yaw present. If the pitot is not presented to airflow squarely, the ASI will under-read. Ice blocking the pitot head will prevent further ASI indications.

When flying without an horizon, we can use the trend indications (and the trim) to maintain the attitude, or recover from an unusual attitude. We will come to this later, it is necessary to understand that you cannot chase the ASI with the stick, which is a fast way to losing control of the aircraft.

4c Compass

The magnetic compass suffers inherent errors which is why powered aircraft use gyro compasses. When level the compass will point towards the magnetic North Pole. Unrestrained the compass will also try to align itself with the lines of magnetic flux and these are not parallel with the surface of the earth but have an angle of dip. Any acceleration displaces the centre of gravity of the needle from under the pivot point deflecting the needle and creating error. This occurs when turning or accelerating. The error introduced depends on the aircraft heading, but can be very significant and misleading.



In steady flight this is no problem, however when accelerating or turning significant errors can arise. Power pilots have to learn the errors, but it is useful to remember that they are least when heading south, **Just remember the compass is next to useless unless the wings are level and the aircraft is in steady flight.**

4d GPS

Receiving the Global Positioning System (GPS) signals uses relatively inexpensive equipment. The system has 21 satellites (plus 3 spares), orbiting the earth. The aircraft unit receives signals from satellites, and by triangulation calculates your position in 3 dimensional space. Normally it will indicate if it is not reliable. It is a military system but jamming trials are subject to NOTAM, fortunately these trials are only done in good weather so that the checking aircraft knows where it is!

More expensive GPS equipment is more complex to use. Learn how to use your equipment on the ground. Figuring out how to use it when in the air is stupid and dangerous.

The equipment can be set up to deliver information in many formats. Recommended are to display distances in Nautical miles and bearings magnetic. Ensure you know how the GPS has been set up. A minimum for navigation out of sight of the ground are bearings (degrees magnetic) and distance (nautical miles) to a waypoint. Ensure that the centre of the home airfield is a waypoint and this will not be the BGA turning point. Do not clutter with excess waypoints.

The GPS system will take time to acquire satellites and provide meaningful information. Turn it on in good time before take-off and ensure that it is giving a sensible reading. If a battery fails, you will be without navigational information for several minutes after a change of supply. Do not do this at a critical stage of the flight. Switch to a good battery in good time.

With the GOTO function, the unit will plot a track between your current position and the desired waypoint, however course corrections are to the waypoint, so as to regain track, double the correction.

It is essential to check the waypoint is correctly set up, as part of the pre flight checks, ensure the distance and bearing to your home site makes sense (normally a few hundred feet). Insert the wrong waypoint and you will be directed to the wrong place.

5 Scan

Moving your attention around the instrument panel is called “the scan”. Pilots sometimes go wrong by fixating on one instrument. You must keep the scan moving.

Three basic things you do when you scan the instruments are;

- a. Scan
- b. Interpretation
- c. Control

The *scan* is the process of moving your gaze around the instruments. The instrument scanned depends on the task being performed. In level flight this would be needle, ball, ASI, in a one two three beat.

Interpretation refers to working out what the instruments are telling you, and determining if any corrective action is required.

Control refers to the act of using the controls to make the glider do what you want it to do.

Flying with the aircraft in trim will help ensure the aircraft stays where you put it.

It is easier to fly with an artificial horizon, but for this training you will only use a turn and slip indicator. Pitch attitude indications must be interpreted from the ASI. If you remember your earlier flight training, you will know that it is important to select a pitch attitude and then wait for the aircraft to accelerate or decelerate to the new value. Without either a natural or artificial horizon we must learn to interpret the ASI indications and not react too quickly to fluctuations---this can lead to over controlling.

Scan descending---The ASI should be steady, the variometer shows rate descent, the needle tells you are not turning, the ball confirms you are in balanced flight, the compass confirms your heading the GPS confirms you are on track and the altimeter confirms you are on the approach path.
The scan is needle-ball-airspeed

6 Procedures

6a Daily Inspection

Some Additional considerations, if there is a risk you will need your cloud flying instruments;

- 2 charged batteries
- Test the turn and slip
- Test the GPS
- Check the compass

6b Pre-takeoff checks

During the course you plan to fly on instruments, do the checks as normal, paying particular attention to;

- Master switch on
- Turn and slip runs up (leave it on for the flight)
- Compass makes sense, given your take off direction.
- Radio on and tested
- GPS on, satellites acquired, correct location.

7 Flying skills

Throughout the exercises, the instructor (front seat) will be responsible for lookout

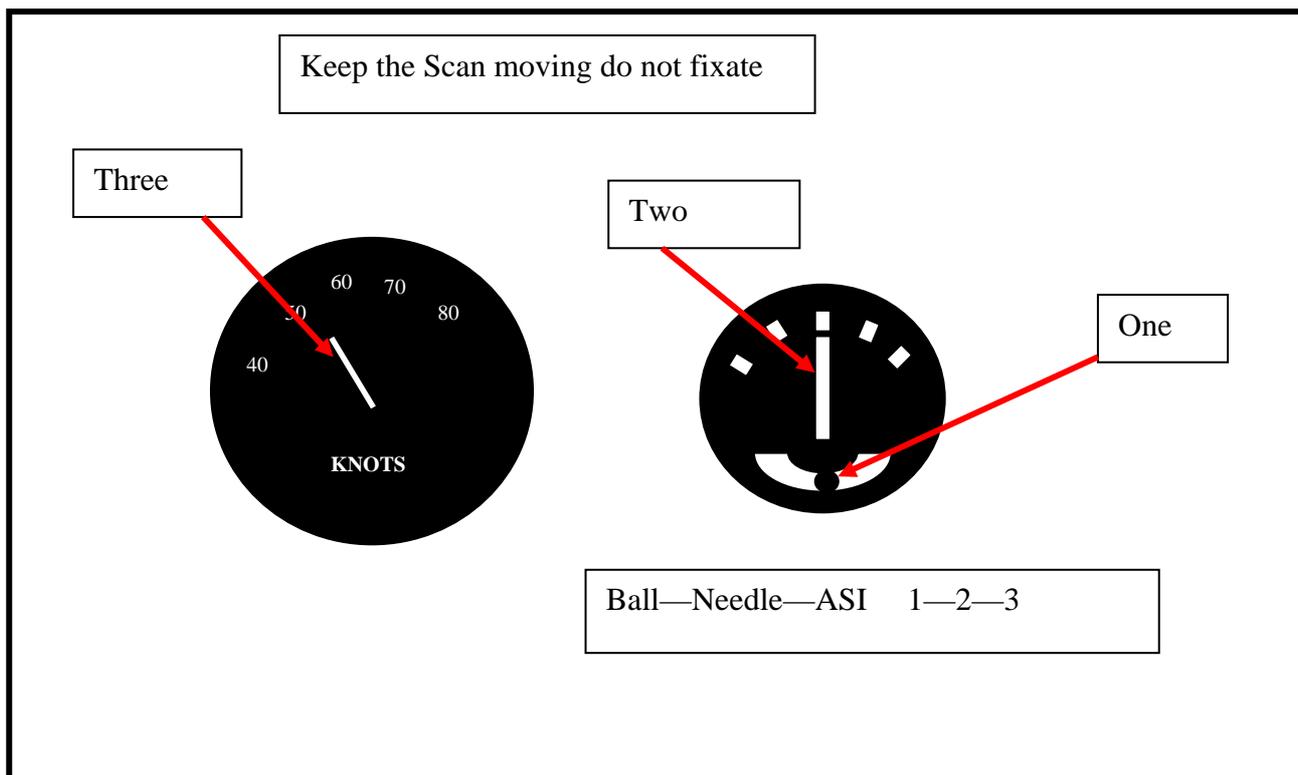
7a Straight glide

During the demonstrations you will be shown;

- How the turn needle will deflect with the aircraft in level flight.
- How to maintain your attitude using ASI trend information and the trim.
- How the ASI can misread in yaw.

Throughout the exercises you must keep the scan moving Ball—Needle—ASI. At this stage do not concern yourself with headings, just practice keeping the wings level and the speed steady.

It is important not to respond re-actively, take a moment to consider your actions. If the ball is not centred, it may not be wise to move the stick (yaw can cause the T&S needle to deflect).



7b Turns and turns onto headings

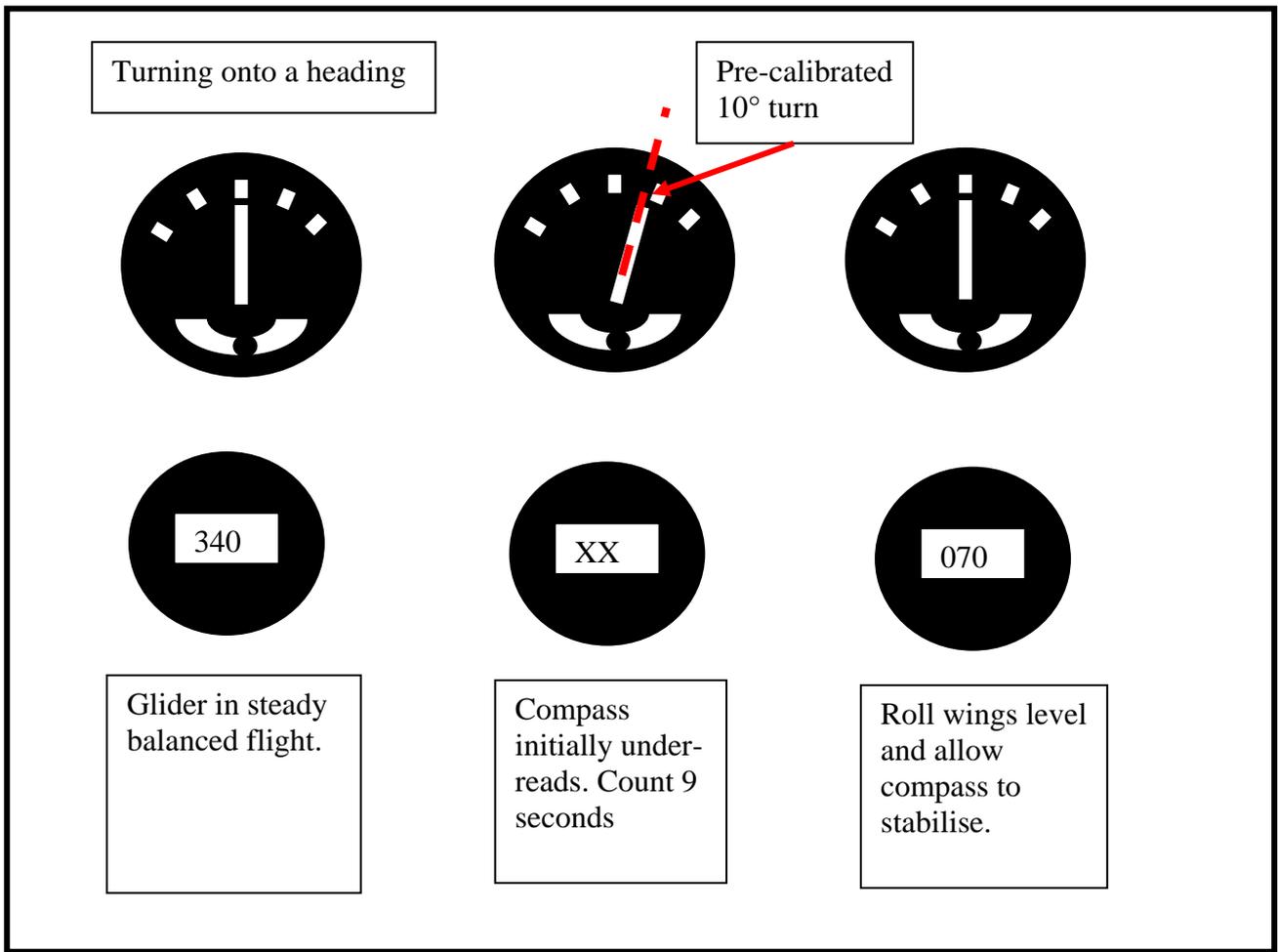
During these demonstrations you will be shown;

- The relationship between needle deflection and rate of turn.
- How to change heading using the T&S and counting the seconds.

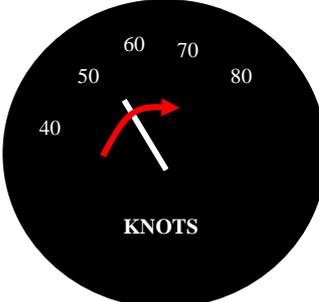
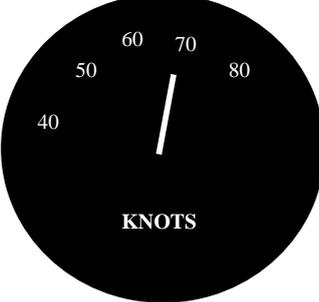
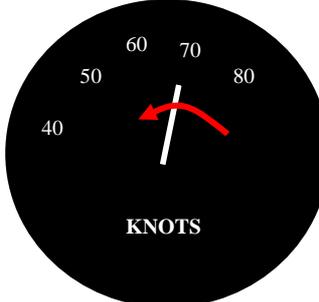
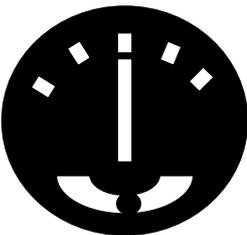
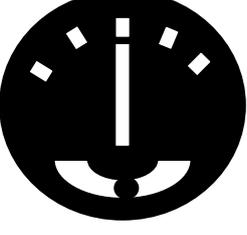
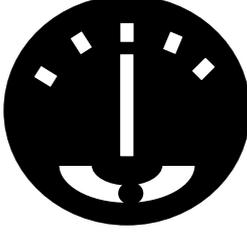
The first part of the exercise is to practice turning. Fly on the first mark [Rate 1] of the Turn and Slip. Never ever let the needle reach the end of its travel. Note how many seconds are required to change heading through 90 degrees. Practice rolling into the reverse turn and note a slight delay as the glider passes through level.

While in steady flight, note your heading. Calculate how many degrees you need to turn left or right on to the desired heading. Roll the glider smoothly to your standard bank angle, using the turn and slip. When turning start counting the seconds (10° per second is about normal in a sailplane). As you reach the desired number smoothly roll the wings level. Just as in clear air, some up-elevator is needed to maintain the turn and after rolling out, this must be reversed. In cloud it is easy to forget.

Example; You are flying on a heading of 340°M and wish to turn onto a heading of 070°M, you need to turn 90° to the right. Roll the glider with right stick and rudder to the standard bank angle, and simultaneously start counting. After a count of 9 seconds roll the wings level, reassess your heading after the compass has settled down. (Assuming your standard bank angle gives 10° per second)



Recovery from a straight Dive

 <p>KNOTS</p>	 <p>KNOTS</p>	 <p>KNOTS</p>
		
<p>Glider in balanced flight---speed increasing. The aircraft is diving</p>	<p>Ease back on stick until needle stops--- then hold the stick still. The aircraft is now in level flight</p>	<p>Pause while the aircraft decelerates.</p>

7c Recovery from straight dive

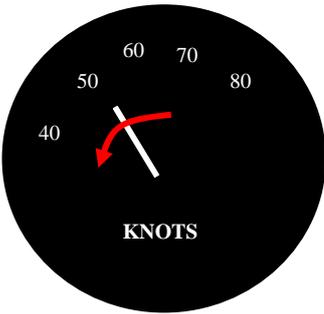
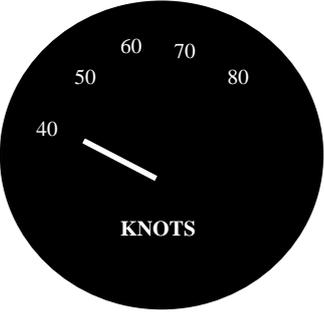
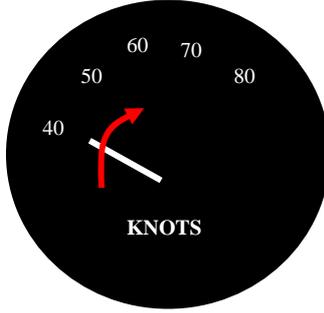
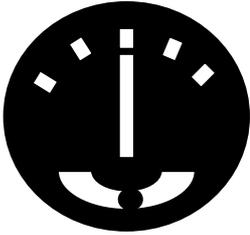
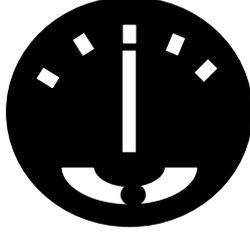
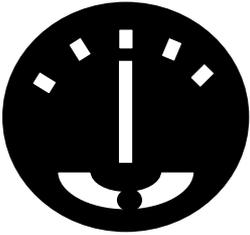
In this demonstration, you will see how to recover from a straight dive. You will see the ASI indications steadily increasing, the needle in the middle and the ball in the middle. Never let the airspeed go above the manoeuvre speed when in cloud.

To recover; ease gently back on the stick until the needle stops moving, then hold the stick until the airspeed stabilises. Re-adjust as necessary and always re-trim.

7d Recovery from straight climb

The recovery is the reverse of the dive recovery. Ease forward on the stick until the needle stops moving, and then hold the stick still while the aircraft accelerates. Readjust as necessary. A stall is not a problem but overzealous recoveries can lead to overspeeding and possible over-stressing.

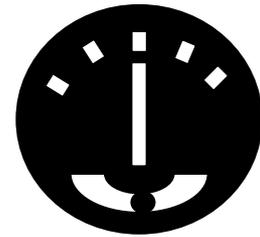
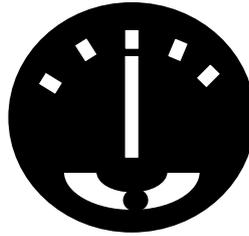
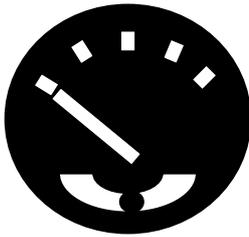
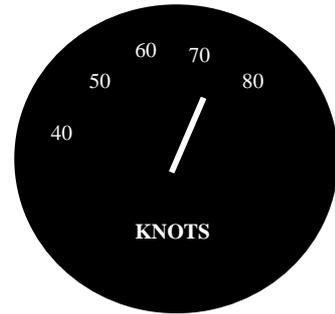
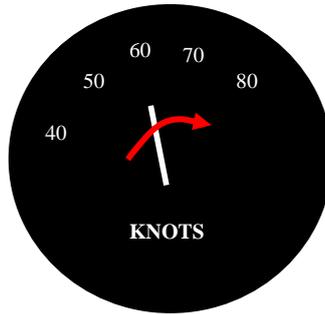
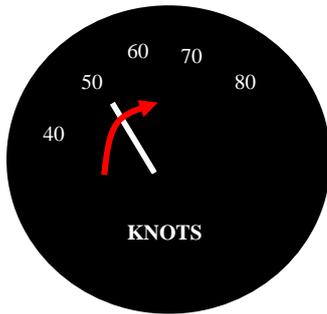
Recovery from a straight climb

		
		
Glider in balanced flight---speed decreasing. The aircraft is climbing	Ease forward on stick until needle stops---then hold the stick still. The aircraft is now in level flight	Pause while the aircraft accelerates.

7e Recovery from a descending turn.

The aircraft is banked and the speed is increasing. Correcting the bank angle is of greater priority than killing the excess speed. The recovery is simplicity itself, roll the wings with co-ordinated stick and rudder until the turn needle crosses and then ease back on the stick until the ASI needle stops moving. Hold the stick while the aircraft decelerates. An incorrect recovery sequence will lead to a spiral dive because in a steep bank, pulling back on the stick does not reduce the speed. Almost all accidents in cloud arise from this cause.

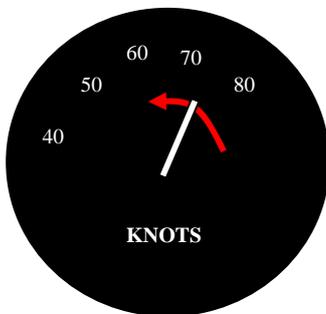
Recovery from a descending turn



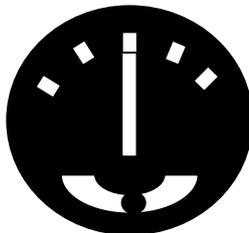
Glider in balanced flight---speed increasing and banked . The aircraft is in a spiral dive.

Roll the wings level with co-ordinated stick and rudder

Ease back on the stick until the needle stops moving. Then hold the stick still



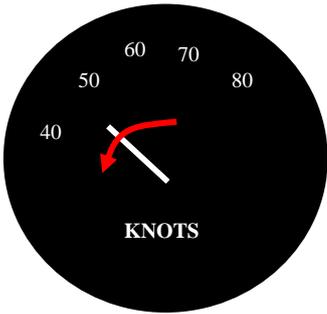
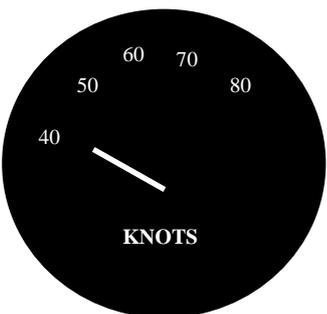
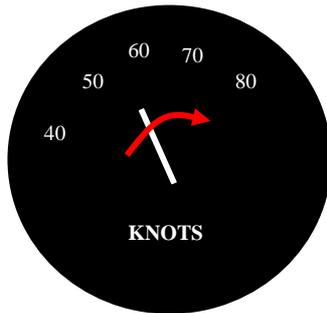
Finally pause while the aircraft decelerates. Readjust as necessary.

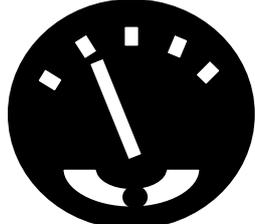
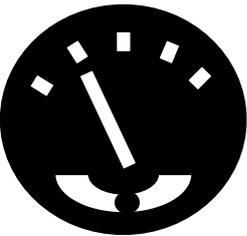
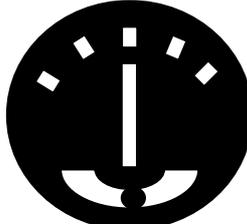


7f Recovery from climbing turn

Recovery action is ease the stick forward until the ASI needle stops moving, hold the stick still while the aircraft accelerates, when the aircraft speed is adequate roll the wings level. An inadvertent stall usually leads to a secondary recovery from a dive. Do not over-control and make this too dramatic.

Recovery From a climbing turn

Glider in balanced flight---speed decreasing and banked. The aircraft is in a climbing turn.

Ease the stick forward until the ASI needle stops moving. Hold the stick still.

As the speed increases, roll the wings level with co-ordinated stick and rudder.

8 Radio

8a frequencies

Frequency	Purpose
Base Frequency (130.1 at Talgarth)	General communications
130.4 Cloud Flying (Cumulus cloud climbs)	Separation in Cloud
121.5 Distress and Diversion	Urgent in flight problems

8b Distress and Diversion (D&D)

D&D can give you a fix, assuming you are high enough, (4000 ft in the Talgarth area)
If you lose your GPS for any reason, D&D may be your only sensible option.

Calls on this frequency should be prefixed by PAN,PAN,PAN for urgency or MAYDAY when there is an immediate risk to life. Practice PAN calls are encouraged, but listen out first to ensure that a real emergency is not in progress.

Airline radios have 121.5 MHz as a function. Wherever you are, a broadcast distress call will normally be heard and can be relayed. If in doubt, call and state the nature of your problem. They will need to know:-

Your callsign, and aircraft type
Position if you know it
Indicated height and millibar setting and heading if airborne
Your predicament (above cloud and unsure of position)
Your request or intentions.

8c Radio procedures

If caught in cloud, it is advisable in the first instance to remain with your home frequency. This will enable you to:-

- a. Obtain information about conditions on the ground.
- b. Warn other local pilots of your imminent descent.
- c. Keep the base aware of your situation, in case they need to get specialised assistance.

DO NOT SWITCH TO 130.4 in this situation because there will be nobody to talk to!!!
Concentrate on flying the aircraft AVIATE—NAVIGATE—COMMUNICATE

Have a clear plan of action, the ground stations will not be able to direct you, but you can tell them your intentions. Obtain an estimate of cloud base, and consider the likely clearance between you and the local terrain. Ask for an estimate of wind speed and direction, to confirm it has not changed since you took off.

If the situation becomes dire, you lose GPS position information or some other problem then call D&D on 121.5. Do not leave this frequency without their permission.

9 Met

9a Conditions to be found in cloud

Apart from other gliders and solid rock, some consideration should be given to the conditions we are likely to meet in cloud.

Airframe Icing will lead to degradation of the wings efficiency and blockage of both the pitot and static vents.

Turbulence can be expected in convective clouds and can be very severe. This makes instrument flying difficult. Electrical discharges can damage the airframe.

Moisture will make the yaw string ineffective (it sticks to the canopy), and the performance of some aircraft is degraded.

A let down through cloud is straightforward for a well trained and well prepared pilot, but never ever let down blind without a navigational fix. It is recommended that you know the freezing level before your flight.

10 GPS navigation

GPS software is continually developing. Early GPS receivers have a limited range of features and can be slow; later units are often extremely fast and sophisticated. There is no substitute for reading the manual and practising in the safety of your own back garden.

10a GOTO function

Most GPS units have a GOTO function. When this function is selected, the unit will present track information between your current position and your planned destination. If you wish to fly a particular path, it is important to press the GOTO function once you are on the desired track (perhaps a final approach path).

Flying directly to your destination can be dangerous if there are obstacles around!!

10b Intercepting a track

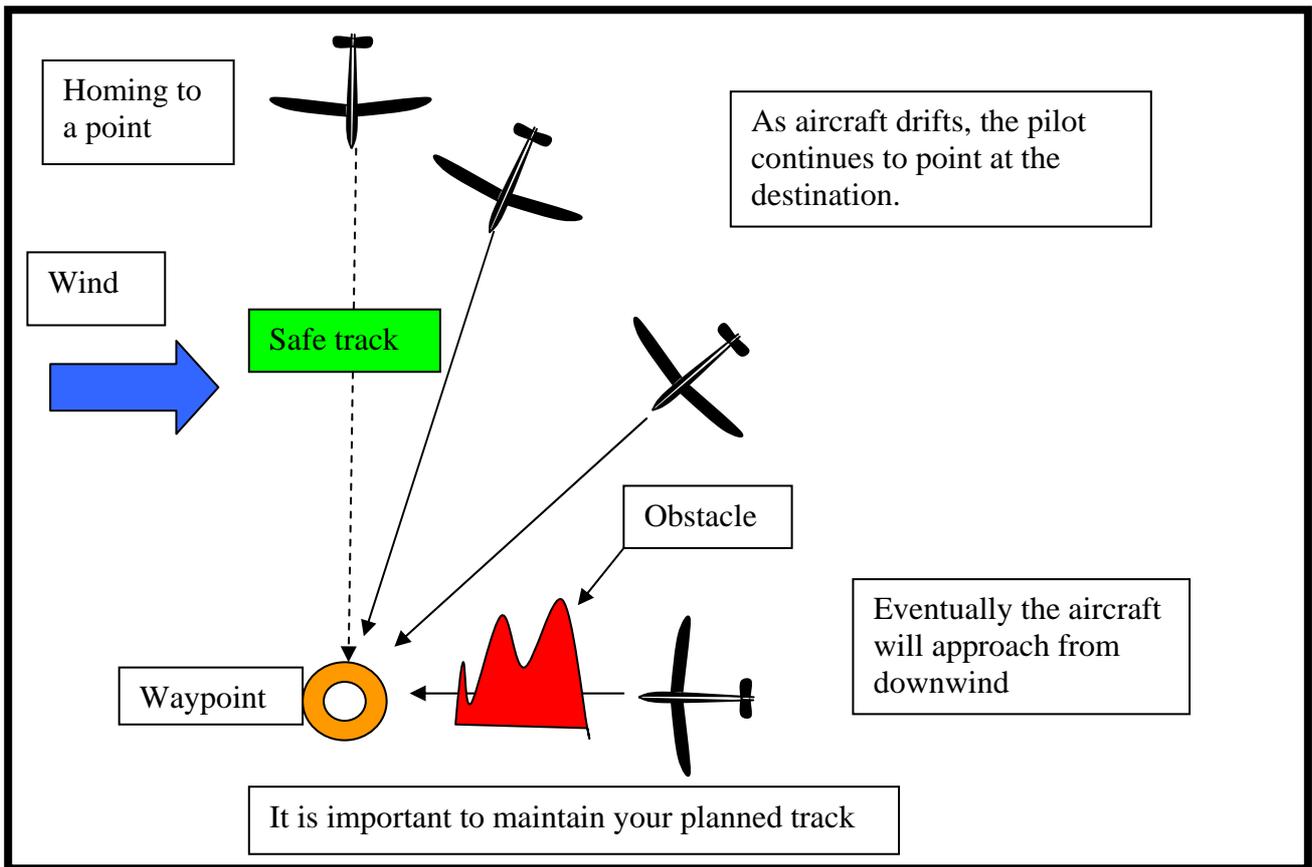
There are two ways we can intercept an approach track.

1. Fly directly overhead your destination using the GOTO function and then fly away from your destination on the reciprocal track. A 180° turn will now place you on track.
2. Fly directly to the approach path interpreting bearing and distance information.

Method one is by far the simplest, but is not always practical.

10c Homing

If your desired track is crosswind, a correction is required to prevent the aircraft drifting off track. If no correction is made and you simply point at your destination, the final approach will ultimately be from down wind.

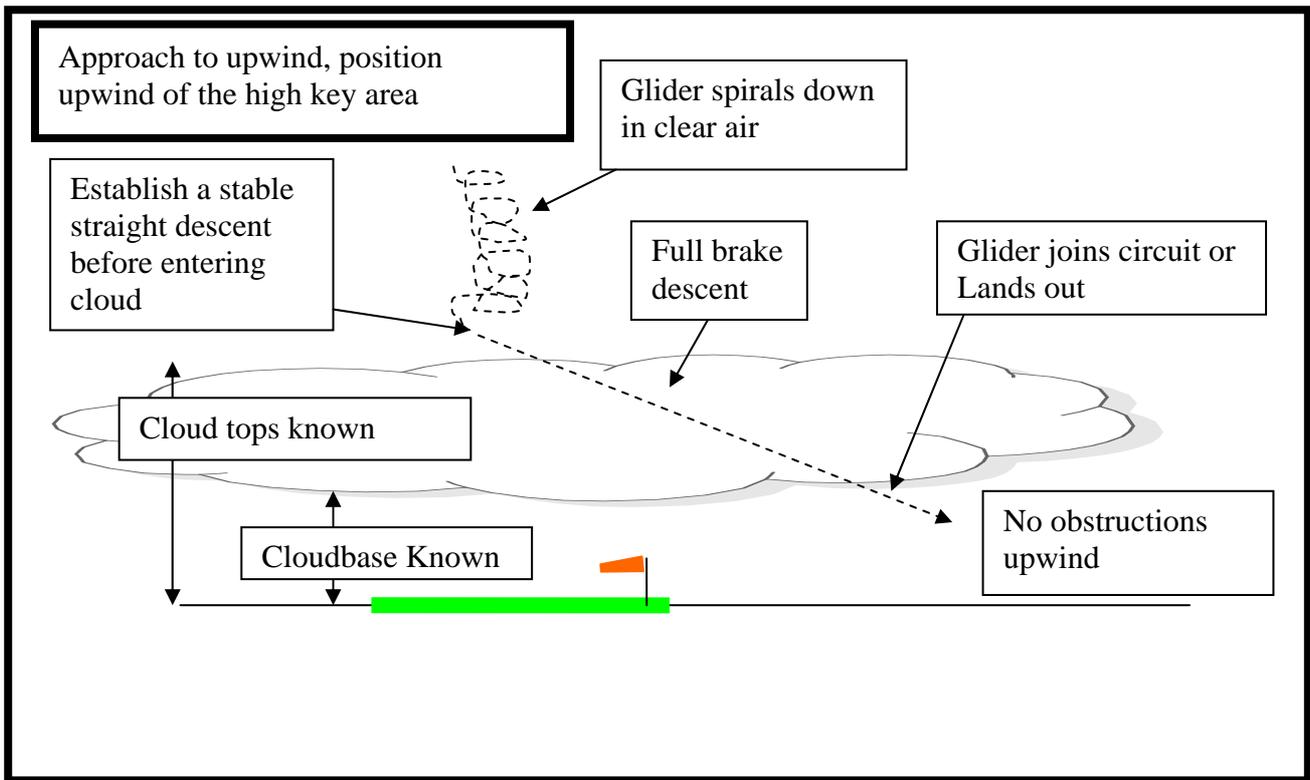


11 GPS Approaches

11a Descent through cloud

By now you realise that gliders are more stable in a steady straight descent with airbrakes open. Spiralling down through cloud is dangerous because of the difficulty in controlling bank angle. To minimise the risk of losing control in cloud, keep it simple. Straight descents with no turns are easier to fly. Complete all your pre-landing checks in the clear air at height, the extra drag of the wheel is an advantage. Be prepared to remove sunglasses, it is dark underneath.

11b Approach to upwind of airfield.



This approach requires minimal navigation.

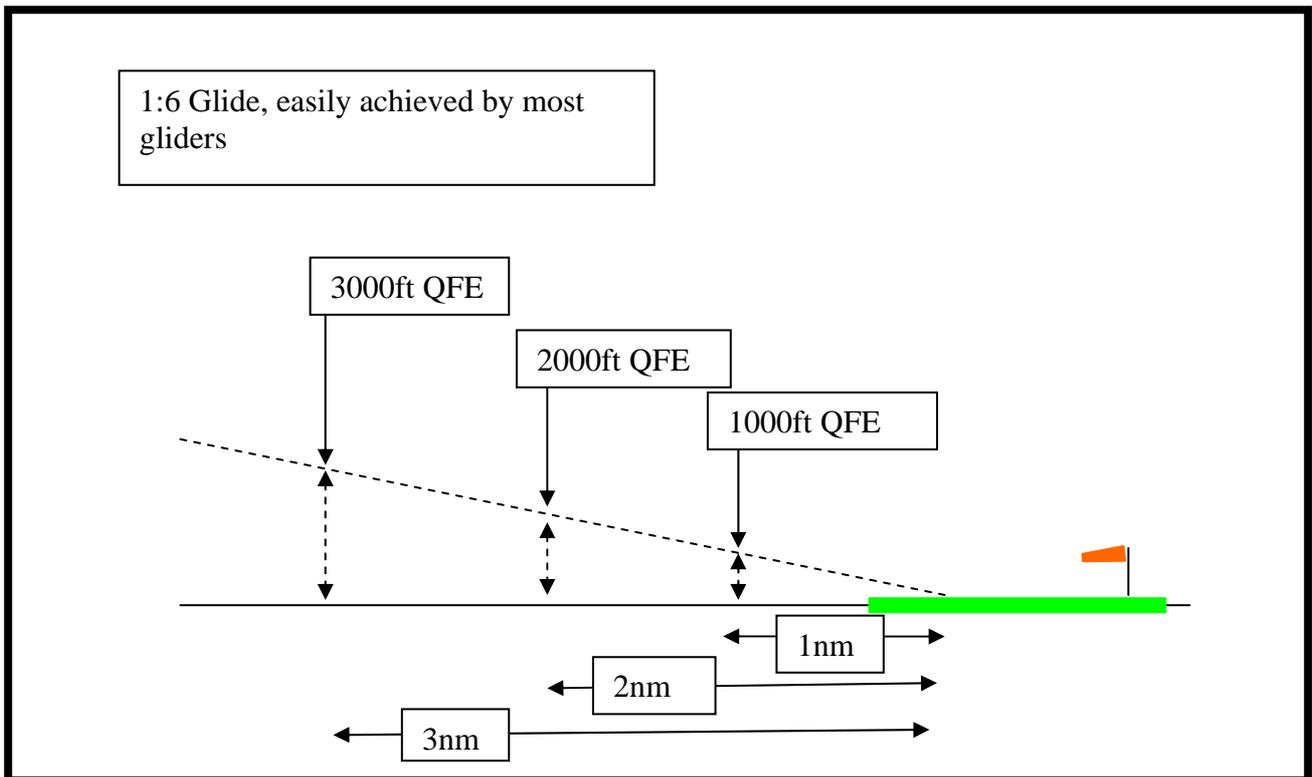
- a. Determine cloudbase and cloud tops heights agl.
- b. Go to directly overhead.
- c. Spiral down to 500ft above cloud tops
- d. Turn into wind.
- e. Stabilise, wings level and open the airbrakes.
- f. Max rate descent at a steady speed, wings level.
- g. When below cloud close airbrakes, establish position.

This approach works well in a westerly wind at Talgarth, but in an easterly wind it would take you into the mountain.

1:6 Approach

A 1:6 approach is achievable by all gliders unless there is a tailwind. It is simple to monitor your progress and permits lower cloud base.

One nautical mile is about 6080 feet, therefore if you are 1000ft above the field and one nautical mile away, you are on a 1:6 glideslope. (2000ft 2nm, 3000ft 3nm, 500ft ½n.m and so on). When you are under a reasonably heavy workload it pays to keep things simple!!



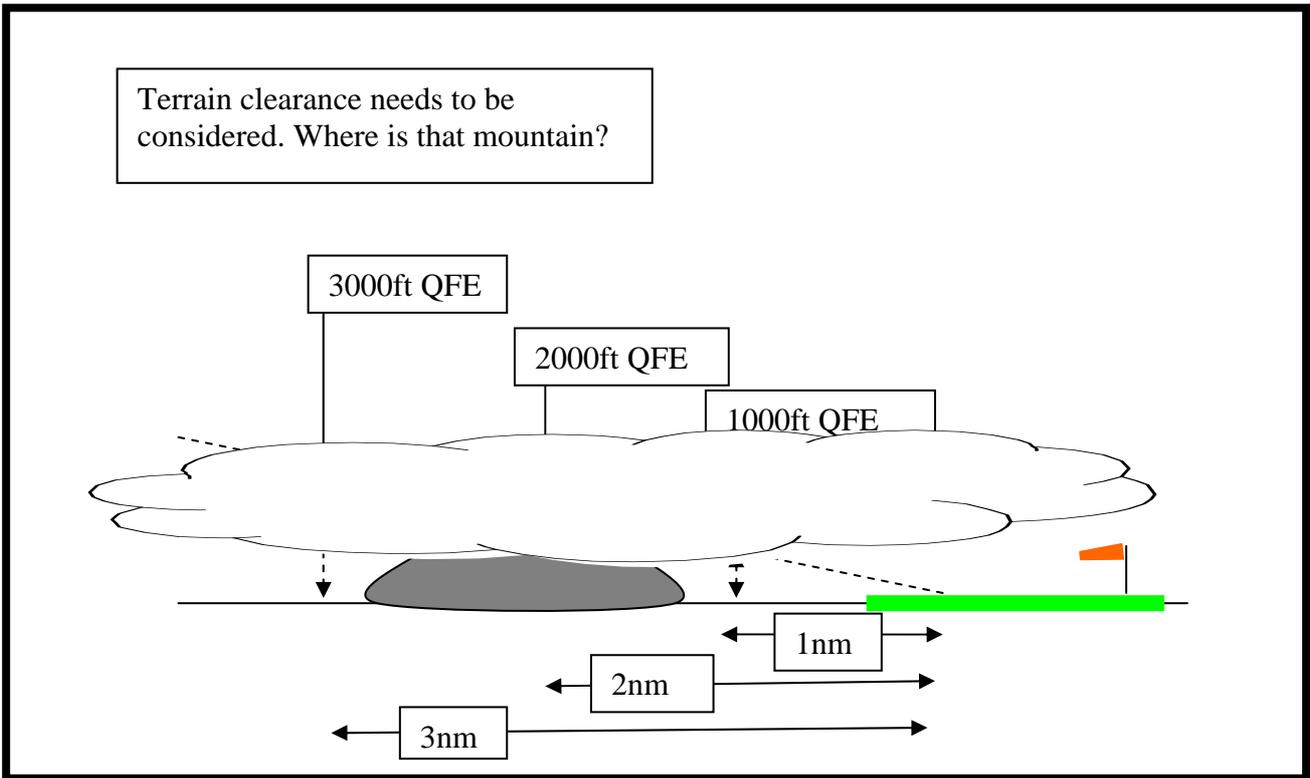
Long stabilised approaches are good news, because you have time to make corrections and there is no need to turn at a critical phase of the flight.

Ensure your GPS is set to nautical miles and not to Kilometres. (2k is approximately 1 nm). You also need your altimeter set to QFE.

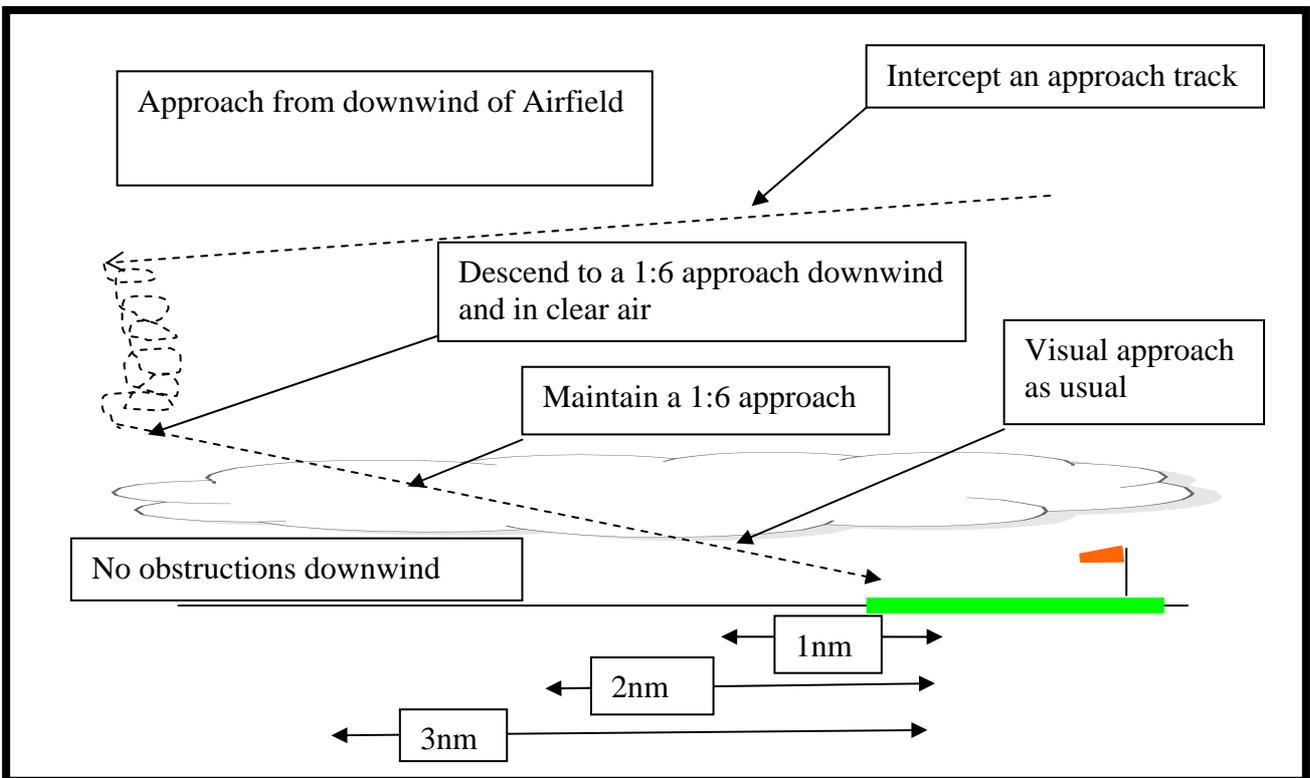
11c Terrain and obstacle clearance.

Its all very well planning an approach into the field using the 1:6 principle, but what about obstructions. If you were to attempt a 1:6 approach into Talgarth from the east, you would get dangerously close to the mountains.

Any planned descent needs to keep you well clear of obstructions. The approach shown in the illustration is unacceptable if the mountain tops are in cloud. (Nicknamed “cumulus granitus”)



11e Approach to downwind of airfield.



This approach requires slightly more sophisticated navigational skills.

- a. Determine Cloud tops and bases

- b. Fly to a position vertically above the desired final approach path and where the range in miles exceeds the cloud top height.
- c. Descend in clear air until on a 1:6 glide path.
- d. Stabilise an approach wings level, steady speed.
- e. Maintain the 1:6 glidepath using airbrake and “matching” distance and height.
- f. When clear of cloud reassess the approach path visually.

This approach works well at Talgarth in easterly winds.

Air Exercises

Flight 1

Not under hood. The objective of the flight is to familiarise the pilot with the instrument anomalies and the general procedures. The pilot will be encouraged to respond “reflectively” rather than “instinctively” to any changes, real or apparent.

The student will be in the rear seat, and the instructor/coach will be responsible for lookout and general in-flight safety.

1 ASI

- Trim and stick position
- Pitch control exercise with ASI
- Inaccuracies induced by YAW

2 TURN & SLIP

- Calibration exercise
- Select needle deflection.
- Inaccuracies induced by YAW

3 FLYING BY INSTRUMENTS

- Scan ball--Needle--ASI
- Straight and level
- Turns
- Turn onto a heading.

4 UNUSUAL ATTITUDES

- Climb
- Dive
- Climbing turn
- Spiral Dive
- Stall

5 NAVIGATE AN APPROACH

- Pre-brief

- Using GPS and turn and slip, fly an appropriate approach for the day.

Flight 2

The student in rear seat and under the hood.

The instructor is responsible for inflight safety, lookout, take off circuit and landing.

Exercise

- Tow to a minimum of 3500 ft, (unless hill or wave soaring is possible)
- Practice recovery from unusual attitudes and turns.
- Navigate a pre briefed approach, with practice radio calls.
- Instructor takeover for circuit and landing
- debrief