026 Teaching Instrument Flying

(Instructor Training Notes)

Flight without external reference is a skill which can be taught when the glider pilot has achieved a basic proficiency in soaring, this implies a minimum of Silver 'C' achievement. It is not safe to attempt to fly in cloud without formal instruction, modern low drag sailplanes will accelerate very rapidly if control is lost, exceeding their limiting airspeeds. Aeroelastic distortion can prevent recover or lead to structural failure. When in cloud, the manoeuuvre speed should be regarded as a limiting speed. Gliders designed to JAR 22 do not have speed limiting airbrakes.

Instrument flight is utilised by gliders in two circumstances:

+ Climbing in convective cloud.
+ Descending through cloud after soaring in lee wave.

TRAINING OBJECTIVE

The objective of training is to enable the glider pilot to fly and navigate safely in cloud, controlling both the aircraft attitude and direction. To maintain geographical orientation.

MINIMUM EQUIPMENT

The training can be conducted in a glider, either from a site with soaring opportunities or using high aerotows, or in a motor glider. Parachutes should be worn when flying in cloud. All instruments need to be calibrated, the compass swung and a deviation card fitted. Two batteries or an engine assure electrical power. Ideally the aircraft should be capable of being trimmed to zero stick load within the speed range from just above the stall to the manoeuvre speed, throughout the permitted centre of gravity range. In addition to the basic glider instrumentation, the minimum equipment required is an electrically driven 'Turn and Slip', a GPS on a fixed mounting, and a radio. It is recommended that an 'Attitude Indicator' is not used for initial training because this leads to over-reliance on a single instrument. A temporary modification to exclude external vision is required and because of the wide visual fields from gliders, the vizor used in powered aircraft is inadequate. A satisfactory arrangement is for the student to fly from the rear seat of a tandem trainer with a GPS being mounted on the instrument binnacle. A translucent screen is mounted between the cockpits and a sheet is fitted around the inside of the rear transparency. Horticultural corrugated polythene is a suitable material for this purpose and can be removed in an emergency. Opaque dried polish has been used, but is not recommended because the residual solvent fume can increase the liability to airsickness.

GROUND INSTRUCTION

Although the student is already an experienced glider pilot, it will not be appreciated that flight using instruments is like learning to fly again. The slow response of instruments compared to visual cues means that all control movements have to be very leisurely. The need to interpret instruments for indirect indications of attitude and position and make the necessary corrections requires the learning of new control loops. Before flight it is essential that the student understands that:

+ In cloud the human organs of balance are positively misleading, this is because small rates of angular movement are not detected, but the faster correcting movement is remembered, leading to leaning sensations. When flying balanced turns, the sensation of gravity does not assist vertical orientation. Large head movements when turning can cause further false sensations. Visual information is the only reliable source for orientation.

+ The turn needle of the 'Turn & Slip' is controlled by an electrically driven tied gyro which precesses when horizontally rotated, but is constrained by a spring. The turn needle indicates aircraft yaw, and deflection to the first mark typically indicates a yaw rate of some 10-12 degree per second. This differs from powered aeroplanes where a Rate 1 is calibrated to 3 degrees a second. A normal balanced turn comprises both yaw and pitch, and an indicated Rate 1 is a comfortable thermal turn for gliders. Deflection of the slip ball indicates that the turn is not balanced and demands a correction with rudder [push on the side to which the ball has fallen, or kick the ball into the middle]. So long as the ball is in the middle, the turn needle is a useful indicator of angle of bank.

+ The Airspeed Indicator [ASI] provides an indirect indication of pitch attitude, the direction and rate of movement of the needle is more important than the speed itself. When the nose is below the normal glide angle, the speed will be increasing. If the stick is moved back [assuming the wings to be level], there will come a moment at which the speed stops increasing, and then the aircraft will nearly level, although it may take some time for the speed to stabilise in accord with the pitch attitude. When speed is reducing, the nose has to be above the glide angle, but a very small forward movement of the stick is the correction required. A stall is uncomfortable but not dangerous. Negative 'G' sensations occur in cloud and a steep nose down attitude is potentially lethal. In icing conditions, the airspeed indicators fitted to gliders are vulnerable to failure from pilot head blockage.

To a power pilot, the vertical speed indicator and changing height shown by the altimeter can be useful secondary indications of attitude. To a glider pilot flying an aircraft of low mass, and intentionally being in a cloud which contains large vertical motions, these are not useful.

+ Control: Bank is recognised because the yaw in the subsequent turn is indicated by the turn needle. To maintain control it is essential that the wings are level or that the bank angle is controlled within narrow limits. When the aircraft is in a spiral dive, the speed cannot be reduced by the elevator without first levelling the wings. To compound the problem, the turn needle will over read when 'G' is applied, making it even more difficult to recover to wings level. The primary and continuous scan of instruments is 'NEEDLE-BALL-AIRSPEED'. If speed or bank angle varies from quite narrow limits, the priority is to regain control of the attitude. This is done by observing the turn needle, rolling the aircraft in the opposite direction until the needle crosses the mid point, centralising the ailerons, noting the movement of the ASI and applying elevator until it stops. Then there is a long wait while the aircraft stabilises. Small further corrections may be required. A problem for glider pilots is that a change in turn or speed indication can be caused by turbulence rather than inattention. If this is suspected, delay any correction because no change in attitude may have occurred. Over controlling is the usual reason for a loss of control.

+ Global Positioning by Satellite [GPS] allows a glider pilot to navigate without external reference. It is important that the student is fully familiar with the instrument before flight because the settings and modes can be complex. For local flying the Club site must be entered as way points. The student has to be capable of monitoring the airborne position in relation to the home site, observing track and ground speed, and establishing a safe approach line using the GOTO facility. All this should be practised on the ground before flight.

+ A Radio is essential to maintain separation from other gliders in cloud, to confirm cloud base before descending in wave conditions, and for use in emergency. Before flight in cloud, the student should know the frequencies used and be able to select these in the air [In some two seaters, this may have to be done by the instructor in the front]. Ensure on the ground that the student knows use of call signs and the appropriate radio phraseology.

+ Meteorology should be revised to ensure that the student is aware of those factors which affect gliding flight in cloud. The difference between the dry and saturated adiabatic lapse rates consequent upon the energy released by the condensation of water vapour. Ice formation and the dangers of lightening and hail in big convective clouds. The formation of lee waves and their associated cloud patterns, strong upper winds and rotor turbulence.

+ The need for additional oxygen above 10,000 ft should be revised.

+ Local airspace limitations should be revised, and the bases of controlled airspace marked on maps together with GPS ranges and bearings.

AIR EXERCISE [1]

The first instrument training flight is conducted in clear air and soaring conditions with no screens fitted. The purpose is to demonstrate and practice:

Flight using instruments while maintaining visual reference for comparison.
Straight glide, holding headings, straight descent using airbrake.
Turns, exit on headings.
Recovery from unusual attitudes
Emergency recovery
Use of GPS

+ Daily Inspection: Confirm batteries charged and sufficient capacity for exercise. Fit GPS.

+ Pre-Flight: Instrument check. Confirm GPS has acquired and is giving 3D navigation. Confirm magnetic compass is aligned with runway heading. Switch on Turn gyros.

+ In flight, on aerotow or thermal soaring: Compare the indication of the turn needle with the angle of bank. When height has been gained, time a full circle to measure the indicated Rate 1 Turn and calculate the rate in degrees per second. Point out the compass readings during the turn and explain that it can only give a reliable indication when the wings are level and it has had time to stabilise. In level flight compare the compass heading with the track shown by the GPS. In free flight demonstrate that a flat yaw will deflect both the turn needle and the slip ball without any bank being applied. In a steep turn demonstrate that application of ‘G’ will causes a large deflection of the turn needle. Demonstrate that when rolling from one turn to the other, the needle will cross the centre line, and that if the stick is centralised as the needle crosses, the residual bank angle will be small. Revise the elevator movements on entry to, and exit from turns. All these to be practised by the student and do not procede further until competent. Demonstrate that with a low nose position the speed will be increasing, and that when the nose is raised, the speed will stop increasing as the glider passes through the normal glide angle. Demonstrate that if the stick is centralised at this point, the speed will slowly stabilise and the residual error will be small. Explain that only small and gentle stick movements are desirable, and it is essential to await the effect of a correction before making further movements. Allow the student to practise until proficient. Finally demonstrate the pitch changes experienced when extending and retracting airbrakes. Demonstrate the increased pitch stability with airbrakes extended and explain how this is used during descent through cloud.

+ Straight glide: It is essential that the student can fly straight and remain on a selected heading. Demonstrate the exit from a turn on to a given heading by noting when the glider passes south and compass errors are at a minimum, timing the turn until the glider nears the desired heading, rolling out, establishing the compass and track readings, and then making secondary corrections. Show how accurate trimming makes speed control easier, the secret of good instrument flying is to put the aircraft into the desired attitude and when a steady performance is indicated, trim to maintain that attitude. Practice speed control with extension and retraction of airbrakes.

+ Unusual attitudes: Place the glider in a descending turn and point out the instrument indications. Turn needle deflected and increasing airspeed. Demonstrate the recovery, extend airbakes if approaching manoeuvre speed, level the wings using the turn needle, then raise the nose until the ASI needle stops moving, waiting for stabilisation and then make final attitude adjustments. Place the glider in a climbing turn, but because the speed is low and decreasing, the controls are relatively ineffective. Again level the wings and it is sufficient to centralise the elevator. Point out the danger of excessive forward movement of the stick, in cloud it is easy to mistake reduced ‘G’ for the stall and attain an excessive nose down attitude. Allow the student to practise. Point out that unlike a steep nose down attitude, a stall is not dangerous. No modern glider will maintain a spin without full pro spin control being held. Refute the heresy that a spin is a useful method of descent through cloud.

+ Emergencies: To enter cloud without gyro instruments running, or to have a failure of instruments in cloud, is an emergency. The pitot head may be vulnerable to icing. To escape, extend the airbrakes and centralise the stick. This action is to be demonstrated to, and practised by the student. In cloud there is an ever present risk of loss of control and a danger of excessive speed. It is recommended that the maximum planned speed in cloud is 10 kts below the manoeuvre speed to remain well within the green sector of the ASI. If this speed is exceeded, the airbrakes are to be extended, wings levelled and the stick centralised. This action is to be both demonstrated and practised in clear air.

+ Navigation: The GPS is to be selected to ‘Nearest Way Point’ and periodically the student is to be asked for the distance and bearing to the home airfield, the GPS readings being contrasted with their visual impressions. Track and groundspeed should be compared with heading and airspeed, and the wind estimated. At a point in the flight when the approach heading to the runway in use is crossed, the GOTO can be selected. This will establish in the memory of the GPS, the extended centre line of the runway in use. When the time comes for return, this centre line may be intercepted down wind of the airfield at a height where the range in nautical miles matches the height in feet [giving a 1:6 final approach angle] This may require a short outbound leg. The student then directs the instructor to fly a straight in approach calling heading changes and the range in miles, the Instructor matches the height to the range and this can be flown down to 500 ft and half a mile providing a convincing demonstration of the GPS capability.

+ After landing, ensure all electric instruments are switched off.

AIR EXERCISE [2]

The second air exercise is a repeat of the first, but conducted under a translucent hood. The sequence of instruction is the same, except that the emergency actions are not re-demonstrated, however it is almost inevitable that they will have to be practised, perhaps after prompting by the instructor. Until proficiency is demonstrated under the hood, actual flying in cloud should not be attempted.

CONVECTIVE CLOUD FLYING

This has to await suitable soaring conditions. There needs to be strong convective cells with extensive gaps between the clouds and no evidence of cumulo nimbus development. Established in a strong thermal and well below the cloud, instruments switched on, first decide the escape heading which will be the shortest route to clear air and then determine the exact position, confirming with the GPS. Be aware of any controlled airspace. Change radio frequency to 130.4 MHZ and broadcast position and intentions to other gliders in the area. If contact with another cloud flying glider is established, separation is by mutual agreement. So long as the glider remains centred in the convective cell, the lift is usually smooth and strong. Continuously scan the turn needle, the slip ball and the airspeed. If an Artificial Horizon is running, this becomes the centre of a radial scan, but must not be the only instrument observed. Above the freezing level, monitor the ASI for small movements because it is vulnerable to pitot head icing. Failure is indicated by a freezing of the indication. Inaccurate turning is the usual cause of losing the lift. Turbulence is associated with losing the lift or reaching the top of the cloud. In either case roll out on to the escape heading and leave the cloud. Once clear, make a transmission on the cloud flying frequency. Using an Artificial Horizon it is possible to recentre, but this is almost impossible with a Turn & Slip alone. Out of cloud, it is essential to confirm position and make an estimate of the upper wind by comparing the heading and airspeed with the track and groundspeed shown by the GPS.

WAVE FLYING

Atmospheric waves occur in stable air masses and are associated with strong winds. The airfield will be in a mountainous area and often the cloud base is below the safety height. While above the inversion the air is usually clear, but visibility at low level may be poor. To climb up through the cloud is usually impracticable because of the difficulty in holding a position and severe airframe icing in the rising cloud. However when established at height, it is common for the cloud gaps to close underneath, and so glider pilots flying in wave conditions should have the capability of navigating above cloud and descending safely through the cloud. An instrument descent to an airfield should not be attempted without first being practised in clear air. The layer clouds associated with wave often have a low base and can be very turbulent, containing embedded rotors. Because of local high ground, the gliding club may have a planned let down pattern. If not, the simplest plan is to descend from directly overhead, tracking into wind [track and heading being the same] aiming to break cloud just upwind of the circuit. Before descending it is essential to be in radio contact and to establish the cloud base and express intentions. Always plan for the minimum of turns in cloud. While at altitude, always consider the possibility of making a diversion to a safer airfield. Because of turbulence at low level, all pre-landing checks, except for flap, are to be completed above the cloud tops. To minimise the possibility of icing or loss of control, the descent through the cloud should be as steep as possible and avoid any turns. Unlike the magnetic compass, the GPS track indicator has no errors so long as there is an adequate ground speed. Flight with airbrakes extended increases pitch stability. The selected speed should be at least 10 kt below the manoeuvre speed. When a direct runway approach is planned, and is permitted by high ground, use the GOTO facility and fly a descent of 1000 ft a mile [1 in 6] This can be be achieved by any modern glider flying into wind. If a downwind descent is planned, do not expect to be able to lose more than 500 ft a mile, even with full airbrakes. In the event of GPS failure, remember that a fix can be obtained on 121.5 MHZ, and this should be demonstrated by a practice ‘PAN’ call.

RPS\ ...\bga.08 07/02/10