CIVIL AVIATION AUTHORITY OF NEW ZEALAND
Te Mana Rererangi Tūmatanui o Aotearoa

Advanced Manoeuvres

The order of the next ten lessons will be dictated by conditions on the day. It is expected that the student be sent solo to practise these manoeuvres in the training area on a regular basis between dual lessons. Please refer to your CFI.

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Contents

Steep Turns

For the purposes of the pre-flight briefing a steep turn is defined as a turn of more than 30 degrees angle of bank, and common practice is to teach the exercise using a 45-degree angle of bank. Good training practice means higher angles of bank, up to 60 degrees, should also be experienced.

The steep gliding turn has been incorporated within this briefing as one method of presenting the material. Some organisations prefer to present a separate briefing on steep gliding turns (refer CFI).

Objectives

To change direction through 360 degrees at a constant rate, using 45 degrees angle of bank, maintaining a constant altitude and in balance.

To become familiar with the sensations of high bank angles and high rates of turn.

To turn at steep angles of bank while gliding.

Principles of Flight

Define the steep turn as a level turn at 45 degrees angle of bank.

Explain that the steep turn is taught to increase the student's coordination and skill, but the manoeuvre can also be used to avoid an encounter with cloud, terrain or other aircraft.

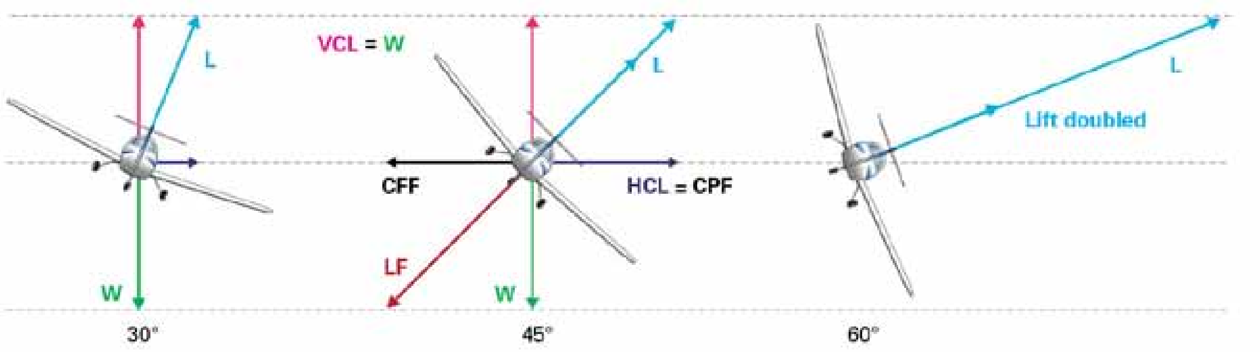
In this exercise the turn is continued for 360 degrees, rolling out on the original reference point, but if you were trying to avoid something you would not turn through a complete circle.

Steep gliding turns will also be covered as applicable to the *Forced Landing without Power* lessons, to cover the situation where the base turn needs to be steepened and to guard against the tendency to pull the nose up as a result of the high descent rate.

Start with a revision the forces in the level medium turn. There should be no need to start with an explanation of the forces in straight and level.

Because we wish to turn at a greater rate we need an increased turning (centripetal) force. To achieve this, we bank the aeroplane to a steeper angle than in a medium turn, thereby providing a greater acceleration towards the centre of the turn.

Figure 1



However this inclination of the lift vector decreases the vertical component of lift, therefore increased lift is required in order to provide sufficient vertical component to equal weight. This also further increases the horizontal component, tightening the turn even further.

> An example of increasing the bank even further should also be given. An angle of bank of 60 degrees is recommended (refer CFI) because at this point lift must be doubled to maintain altitude.

To this point the discussion has mostly been revision; now the acceleration forces acting on the aeroplane are described.

The acceleration force opposing CPF is centrifugal force (CFF). This is the acceleration that tries to pull the aeroplane out of the turn. These two 'forces', CPF and CFF, explain why water in a bucket does not fall out when the bucket is swung overhead.

The acceleration pushing the pilot into the seat is known as *load factor* (commonly referred to as G). This is equal and opposite to lift, and the wings must support it. Therefore, in level flight, where:

$$\frac{L}{W} = LF \quad \frac{1}{1} = 1 \text{ or } 1\text{ G}$$

At 45 degrees the load factor is +1.41 and at 60 degrees angle of bank the load factor is doubled, +2 G, and the student will feel twice as heavy.

> Some organisations mention the effects of banking at 75 degrees (this may be deferred to Max Rate Turns, refer CFI) where the load factor is increased to +3.86 (nearly +4 G). This is usually done, only for the purpose of showing that the relationship between angle of bank and G, as well as stall speed, is not linear.

Although your drawing will show all the 'forces' equal and opposite to each other, the aeroplane is not in equilibrium!

Equilibrium is a state of nil acceleration or constant velocity, and velocity is a combination of speed and direction.

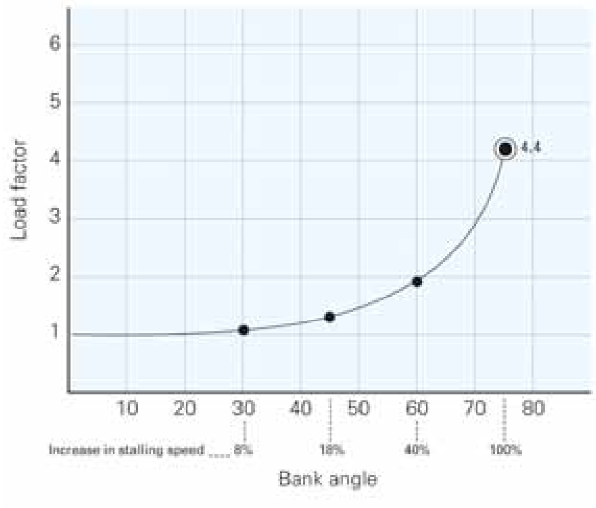
Therefore, although the student may have trouble understanding that the aeroplane is accelerating toward the centre of the turn, the aeroplane is clearly not maintaining a constant direction and therefore, by definition, cannot be in equilibrium.

The load factor is often referred to as *apparent weigh*t – because it is an acceleration (force) that the wings must support, similar to weight.

The effect of this increase in apparent weight, or load factor, on the stall speed is described.

The stall speed in a manoeuvre (V_{SM}) increases as the square root of the load factor (√LF). Assuming a stall speed of 50 knots in level flight, at 60 degrees angle of bank the stall speed will increase by the square root of the load factor +2 (√2), which is approx 1.4. This means that, at 60 degrees angle of bank, the stall speed is increased by 40% to 70 knots.

Figure 2



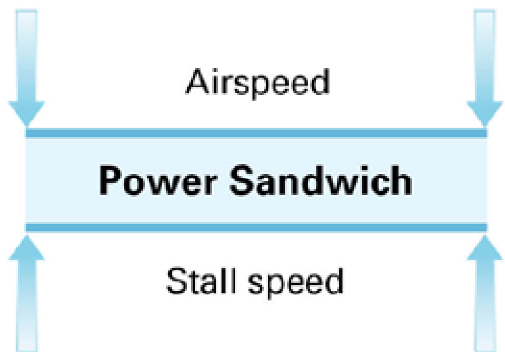
Presentation of the formulas in a preflight briefing is probably not required (refer CFI). However, the numerical effects are normally presented in a table type format.

Angle of Bank	Load Factor	% increase in stall speed	New stall speed
0	1		50
45	1.4	20	60
60	2	40	70
75	4	100	100

At the same time, because lift is increased by increasing the angle of attack, adversely affecting the L/D ratio, the drag also increases – by 100% at 45 degrees, and by 300% at 60 degrees angle of bank. This increase in drag, or reduction in L/D ratio, results in decreased airspeed.

This is an undesirable situation, with the stall speed increasing and airspeed decreasing. Therefore, the power is increased to combat the increased drag to maintain a margin over the stall speed. This can be referred to as a *power sandwich*.

Figure 3



In the medium level turn, the lift and drag increase and the adverse affect on the L/D ratio was so slight that the decrease in airspeed was ignored. However, as the increase in drag, load factor and stall speed is not linear, the effect of increasing drag can no longer be ignored. Therefore, any turn at angles of bank greater than 30 degrees requires an increase in power. At 45 degrees angle of bank this increase will be about 100–200 rpm.

> This explanation coincides with the patter of "through 30 degrees increase power" and is the reason why the steep turn is defined as angles of bank greater than 30 degrees.

All of these principles also apply to the steep gliding turn. However, power is obviously not available to oppose the increasing drag and therefore, at angles of bank greater than 30 degrees the airspeed must be increased with any angle of bank increases. At 45 degrees angle of bank, the airspeed is increased by 20% of the stall speed (about 5 to10 knots) to maintain a similar margin over the increased stall speed.

Revise adverse yaw and how it is countered. The amount of rudder required to overcome the adverse yaw is dependent on the rate of roll. The amount of rudder required is kept to a minimum by encouraging smooth control inputs. At low airspeeds the ailerons will need to be deflected further to achieve the same roll rate of higher airspeeds. This will significantly increase the induced drag and require more rudder to negate the adverse yaw. This will become apparent during gliding turns.

Considerations

Out of Balance

If the aeroplane is out of balance in the turn and rudder is applied to centre the ball, the further effects of rudder must be countered.

As rudder is applied, the correct angle of bank must be maintained with aileron. The resulting yaw will pitch the nose above or below the horizon, and therefore an adjustment to attitude will also be required to maintain constant altitude.

The Spiral Dive

A spiral dive is generally caused by over-banking.

If the angle of bank is permitted to increase, insufficient vertical component of lift will be produced, and the aeroplane will descend. The natural tendency is to attempt to pitch the nose up by increasing backpressure. Because of the high angle of bank, this tightens the turn and increases the rate of descent.

The symptoms of a spiral dive are a high angle of bank, rapidly increasing airspeed and increasing G.

The recovery method is to close the throttle, roll wings level, ease out of the dive and regain reference altitude.

The aeroplane's structural limits are reduced by 1/3 if manoeuvring in more than one plane. Therefore, firmly roll wings level before easing out of the dive.

Steep Gliding Turn

Spiralling down in the modern, low-drag light aeroplane can result in a very rapid increase in airspeed and exceeding the aeroplane's structural G limits. Most older training aeroplanes were not only built to be fully aerobatic but suffered from considerable drag, which generally meant the climb speed, cruise speed and top speed were all about the same, and as a consequence this manoeuvre was recommended as a way to get through a hole in the cloud below.

This is no longer the recommended way to deal with being stuck above cloud – the first step is to declare an emergency. With the current transponder coverage available in New Zealand, it is likely that ATC will quickly identify the aeroplane and provide a heading to steer to a cloud-free area, or another aircraft may be sent to assist.

If descent through a large hole is required (emphasise avoiding getting into this situation in the first place), select flap as required, power to idle and a 45 degree maximum angle of bank should be used, lowering the nose to maintain the selected speed.

Airmanship

State any organisation-imposed minimum altitude for the conduct of level steep turns, and the minimum descent altitude for steep gliding turn practise (refer CFI).

Revise **SADIE** checks and the need to counter the effect of wind to remain within the lateral boundaries of the training area.

Revise any VFR requirements considered relevant.

Ensure sick bags are on board.

Aeroplane Management

Above 30 degrees, power is increased with angle of bank. A 100-rpm increase at 45 degrees angle of bank is only a guide. Beware the rpm limit.

Human Factors

To minimise disorientation turns are made through 360 degrees, rolling out on the same reference point as that chosen before starting the turn. Because of the high rate of turn a prominent reference point should be chosen.

Revise the restrictions imposed by the airframe and the technique of looking in the opposite direction to the turn, starting at the tail and moving forward through the nose of the aeroplane and into the direction of the turn, so as to minimise possible conflict with aircraft directly behind.

In addition the effects of G on vision can be discussed.

For some students the sensation of the turn may be uncomfortable at first. The student should be informed that any discomfort will generally be overcome with exposure and practise, but to speak up early if they are uncomfortable.

Air Exercise

The air exercise discusses entering, maintaining and exiting the steep level turn at a bank angle of 45 degrees.

Entry

A reference altitude and prominent reference point are chosen and the lookout completed.

The aeroplane is rolled smoothly into the turn with aileron, and balance is maintained by applying rudder in the same direction as aileron to overcome adverse yaw.

Through 30 degrees angle of bank, power is increased with the increasing angle of bank, so that at 45 degrees angle of bank power has increased by about 100 rpm. At the same time, backpressure is increased on the control column to maintain altitude.

At 45 degrees, which is recognised through attitude and confirmed through instruments, a slight check will be required to overcome inertia in roll and rudder pressure will need to be reduced to maintain balance.

The indication of 45 degrees bank angle on the artificial horizon should be explained.

Maintaining

Maintaining the turn incorporates the **LAI** scan. Lookout into the turn is emphasised, and the attitude for 45 degrees angle of bank and level flight is maintained.

The effect of side-by-side seating on attitude recognition should be discussed, preferably with the aid of an attitude window.

During the turn, maintain the altitude with backpressure – provided that the angle of bank is correct. Maintain lookout, around airframe obstructions by moving the head.

If altitude is being gained or lost, first check angle of bank. If the angle of bank is correct, adjust backpressure to maintain constant altitude.

> Emphasis is placed here on establishing the correct angle of bank to prevent the onset of a spiral dive.

Exit

Look into the turn for traffic and the reference point. Allow for inertia by anticipating the roll out by about 20 degrees before the reference point.

> Anticipating by about half the bank angle encourages a smooth roll out that is easier to coordinate.

Smoothly roll wings level with aileron, balance with rudder in the same direction to overcome adverse yaw, and relax the backpressure to re-select the level attitude. Through ________ knots reduce power to cruise rpm.

Steep Gliding Turn

The steep gliding turn may be given either as a separate briefing before steep level turn revision (refer CFI) or demonstrated and practised in this lesson.

Enter a steep gliding turn from straight and level cruise by:

- applying carburettor heat,
- closing the throttle,
- rolling to 45 degrees angle of bank,
- maintaining height until the nominated airspeed is reached, and
- lowering the nose to maintain speed.
- Trim.

With the medium gliding turn established, the angle of bank and airspeed are increased at the same time, to 45 degrees angle of bank and ________ knots. This sequence is followed as it is the most probable sequence of events during a forced landing. If it is known beforehand that a large bank angle will be used, the airspeed could be increased in advance. However, it is more likely that the requirement for a steep turn will not be recognised until part way through the turn onto final with a tailwind on base.

In the steep gliding turn, the attitude must be adjusted to maintain the nominated airspeed.

> The decision to demonstrate an out-of-balance situation and the spiral dive should be referred to the CFI.

Airborne Sequence

The Exercise

The student should be capable of taking you to the training area, while operating as pilot-in-command. This will include making all the radio calls, making the decisions about which route to take, what altitude to climb to, and keeping a good lookout.

Once established in the training area, have the student practise medium level turns.

Emphasise lookout before and during the turn.

Take control and patter the student through the first turn. Then have them practise in that direction, while you correct any mistakes. Then have them try on their own, with no input from you until the end. Then take over and demonstrate in the other direction and follow the same sequence.

During one of the demonstrations, either left or right, ask the student to lift a foot off the floor so as to experience the effect of G.

Discourage any tendency by the student to lean out of the turn.

Once the student has completed satisfactory steep level turns both left and right, the effects of an out-of-balance situation and/or the spiral dive may be demonstrated or practised (refer CFI).

The majority of the lesson will be the student practising the turn. By the end of the lesson they should be able to tell you what they need to work on in future.

On your return to the aerodrome, it may be a good time to practise a forced landing, or an overhead rejoin.

After Flight

The next lesson will either be *Maximum Rate Turns* or *Wing-Drop Stalling*. Remind the student that you will be expecting them to practise these exercises solo, and to have shown improvement when you next fly with them.

Advanced Stalling

This *Advanced Stalling* lesson covers the factors that affect the observed airspeed and nose attitude at the stall.

Although the aeroplane always stalls when the aerofoil is presented to the airflow at too high an angle (>≈15 degrees) most aeroplanes are not fitted with an angle-of-attack indicator. Therefore, it is common practice to use the aeroplane's stalling speed (V_S) as a reference.

In level flight the airspeed and nose attitude will vary depending on the aeroplane's configuration (speed, power, flap and gear settings) and therefore airspeed and/or nose attitude are not reliable indicators unless the configuration for the phase of flight is considered. As was seen in the climbing lesson, the aeroplane has a high nose attitude and a low airspeed but is nowhere near the stall.

The purpose of this exercise is to revise the causes of the stall and to compare the aeroplane's nose attitude and airspeed approaching the stall in various configurations, and then to recover from the stall.

Objectives

To experience the effect of power and/or flap on the aeroplane's speed and nose attitude at the stall.

To recognise the symptoms of the stall.

To stall the aeroplane and be able to recover from the stall by taking appropriate action.

Principles of Flight

The aeroplane's manufacturer provides stalling speeds for one or more configurations as a guide to the pilot, for example, from level flight with a slow deceleration, power at idle, and flap up, when this aeroplane reaches the critical angle the airspeed will read ______ knots.

Although the critical angle remains constant, the stall speed will vary for other configurations and with several factors.

$$L = C_L \tfrac{1}{2} \rho V^2 S$$

L = angle of attack x airspeed

Lift primarily varies with angle of attack and airspeed. Since the critical angle cannot be altered, anything that increases the requirement for lift will require an increase in airspeed to produce that lift. Therefore, when the critical angle is reached the airspeed will be higher.

↑ L = angle of attack x ↑ airspeed

Anything that decreases the requirement for lift will decrease the airspeed observed at the stall.

The mnemonic 'WILPS' can be used to remind us of the factors affecting the stall; the first three increase the stall speed the last two reduce it.

Weight

An increase in weight will require an increase in lift, resulting in an increase in the stalling speed.

↑ W → ↑ L → ↑ V_S

Ice or Damage

If ice forms on the wing, or the wing is damaged, the smooth airflow over that part of the wing will be disturbed, allowing the airflow to break away earlier. This increases the requirement for lift and therefore the stall speed. The effect of ice is twofold in that it also increases the aeroplane's weight.

In flight, generally ice will form on the airframe only if the aeroplane is flown in cloud.

The most common danger from ice in New Zealand is its formation on the wings and tailplane of aeroplanes parked overnight, and sometimes it is so thin and clear that it is hard to detect. No attempt should ever be made to take off with ice or frost on the wings or tailplane, because of its effects on the smooth airflow and the resulting increase in stall speed – which cannot be quantified and may be well above the normal rotate speed.

Loading

> Explaining this effect is one reason why advanced stalling is often left until after solo circuits and steep turns; before first solo the explanation is kept as simple as possible.

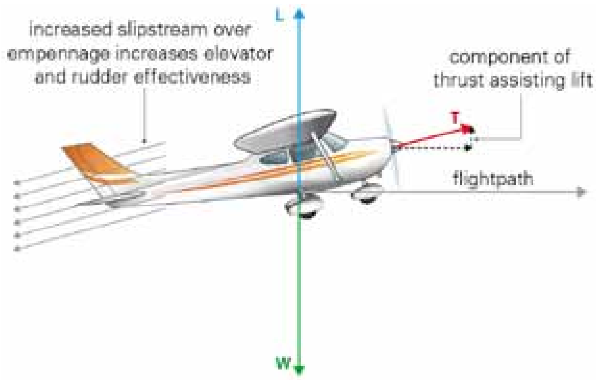
Loading, or load factor, is the name given to the force/acceleration that the aeroplane must support, for example, in pulling out of a dive. When you ride a roller coaster, at the bottom of the dip you feel heavier, as you're pushed into your seat by the force/acceleration of changing direction. You haven't actually gained weight, but it feels that way. For an aeroplane this is often referred to as apparent weight, or G, and this increase in apparent weight increases the requirement for lift, and thus it increases the stall speed.

↑ apparent W → ↑ L → ↑ V_S

Power

If the aeroplane could climb vertically there would be no requirement for lift at all. So when thrust is inclined upwards, it decreases the requirement for lift and reduces the stalling speed. In addition, the slipstream generated by having power on increases the speed of the airflow and modifies the angle of attack (generally decreasing it) over the inboard sections of the wing. The increased airspeed increases the lift and reduces the aeroplane's stall speed, and the modified angle of attack increases the nose-high attitude.

Figure 1



Slats, Slots or Flap

Flap increases lift and therefore the stalling speed is reduced. However, flap also changes the shape of the wing, and this results in a lower nose attitude at the stall.

The effect of flap on the lift/drag ratio should be revised, with particular emphasis on the reason the flap is raised gradually during stall recovery.

Although flap increases lift, it also increases drag – generally, about the first 15 degrees of flap increases lift with little adverse affect on the L/D ratio. It should be appreciated however, that any use of flap will decrease the L/D ratio.

The application of any further flap rapidly increases drag, adversely affecting the L/D ratio.

The point at which drag rapidly increases varies with aeroplane and flap type, but this is usually at the flap setting recommended for a soft-field takeoff.

Slats and slots also increase lift and therefore stall speed is reduced.

Use of Aileron

If at the stall the aeroplane starts a slight roll, using aileron to stop the roll (a natural tendency) will increase the angle of attack on the down-going wing. This decreases the lift even further and increases the drag, continuing the roll not stopping it.

This is the reason for maintaining ailerons neutral in the initial stall recovery and using rudder to keep the aeroplane straight on the reference point.

Airmanship

Reiterate that passengers should not be carried during this exercise.

Situational awareness considers not only the position of the aeroplane three dimensionally within the training area but also the warning symptoms of the approaching stall, and awareness of the flight phase – power reduced but attempting to maintain level flight.

It also includes an awareness of other traffic.

Revise the **HASELL** checklist.

H ***H**eight (not altitude)*
Sufficient to recover by not less than 2500 feet above ground level.

A ***A**irframe*
The entry configuration is revised: power, flap.

S ***S**ecurity*
No loose articles, harnesses secure.

E ***E**ngine*
Temperatures and pressures normal.

L ***L**ocation*
Not over a populated area and clear of known traffic areas, including airfields.

L ***L**ookout*
Carry out a minimum of one 180-degree, or two 90-degree, clearing turns, to ensure other traffic will not result in conflict.

Revise the **HELL** checks.

H ***H**eight (not altitude)*
Regained or sufficient to recover by not less than 2500 feet above ground level .

E ***E**ngine*
Temperatures and pressures normal, mixture RICH, fuel sufficient and on fullest tank, fuel pump ON.

L ***L**ocation*
Not over a populated area and clear of known traffic areas, including airfields.

L ***L**ookout*
One 90-degree clearing turn.

Aeroplane Management

Review the use of carburettor heat.

Revise the need for smooth throttle movements.

Monitor and manage the engine temperatures and pressures between stalls.

Human Factors

The regular turns and steeper than normal nose attitudes could lead to some disorientation. Make sure the student has time between stalls to orientate themselves.

This exercise may produce some discomfort in the student, especially if your aeroplane type has a tendency to wing drop. Reassure the student that this is not a dangerous exercise, when conducted above 3000 feet – as you will be doing. Tell the student that if they feel uncomfortable at any point, they should say so, the aeroplane can then be flown level until they feel comfortable to continue.

Air Exercise

HASELL checks are completed and a prominent outside reference point on which to keep straight is nominated.

Start by carrying out a basic stall entry and recovery as a reference to compare the effect power and flap has on the stall. In particular the student should identify the attitude, speed and recovery references.

Then teach the effects of power on the stall.

Then the effect of flap on the stall.

Finally teach the effect of power and flap combined, on the stall.

Entry

From level flight, carburettor heat is selected HOT and the power smoothly reduced to _____ rpm. As the nose will want to yaw and pitch down, keep straight with rudder and hold the altitude with increasing backpressure.

If selecting flap below _____ knots (within the white arc) select full flap gradually and prevent the tendency for the aeroplane to gain altitude or 'balloon' with the rapid increase in lift, by checking forward or relaxing the backpressure.

Full flap is recommended so that raising the flap can be practised in the recovery sequence.

Through _____ knots, or when the aural stall warning is heard, select carburettor heat to COLD, as full power will shortly be reapplied.

Stall Warning Symptoms

Decreasing Airspeed and High Nose Attitude

The first symptom is decreasing airspeed. The rate at which the airspeed decreases will be affected by the amount of power and flap being used, probably faster in this case with full flap.

Note the effect of power on attitude and airspeed at the stall.

Note the effect of flap on attitude and airspeed at the stall.

Low airspeed and a high nose attitude are not always present in the approach to the stall, as was demonstrated in the no power, full flap case. However, for most phases of flight, low airspeed and high nose attitude are valid indicators; so too is quietness.

Less Effective Controls

The next symptom is less effective control as a result of the lowering airspeed. However, the effectiveness of the rudder and/or elevator will be determined by the amount of power being used. In this case, the elevators will generally retain sufficient effectiveness to bring the aeroplane to the critical angle without a sink developing. Control pressure in pitch will be heavier.

Stall Warning Device

The stall warning device (which is not a true symptom) follows this. Because the stall speed with power and/or flap is reduced, the stall warning will sound later, at a lower airspeed.

Buffet

The last symptom is the buffet. The amount of buffet detected depends on the mainplane/tailplane configuration, as discussed in basic stalling. In both the high-wing/low-tailplane and low-wing/low-tailplane types, the flap deflects the airflow down onto the tailplane, and the buffet will be more noticeable. This will depend on the power setting used, as the slipstream may mask any increased effect. In the low-wing/high-tailplane arrangement there may be little change, but again depending on slipstream effects.

Remind the student to observe the attitude and when the aeroplane stalls note sink and the nose pitching down.

Recovery

The recovery is still in two parts, but coordination and speed of execution are increased.

To unstall

Decrease the backpressure, or check forward, with ailerons neutral and remaining straight on the reference point with rudder. The student should be reminded that check forward with the elevator is a smooth but positive control movement but not a push.

The correct use of aileron must be reinforced to produce the required automatic response.

To minimise altitude loss

Full power is smoothly but positively applied – use rudder to keep straight – and the nose is smoothly raised to the horizon. There is no need to hold the nose down as excessive altitude will be lost, while increasing backpressure too rapidly, or jerking, may cause a secondary stall.

The result is sufficient to arrest the sink and minimise the altitude loss.

Hold the aeroplane in the nose-on-the-horizon attitude and reduce the flap setting (as appropriate to aeroplane type) immediately. Do not raise all the flap at this stage, for example in a PA 38 reduce to one notch of flap, or in a C152 reduce the setting by at least 10 degrees. Any benefit of attitude plus power will be reduced the longer the aeroplane is held in the nose-on-the-horizon attitude with full flap extended.

A pitch change will occur as flap is raised if uncorrected, therefore, the nose attitude must be held constant. In addition, flap should not be raised with the nose below the horizon, as this will result in considerable altitude loss.

Before raising the remaining flap, there are three criteria that must be met;

- safe altitude,
- safe airspeed (above a minimum and accelerating), and
- a positive rate of climb (to counter the sink as a result of reducing lift through flap retraction).

When these conditions have been met, raise the remaining flap and counter the pitch change. The aeroplane will continue to accelerate, and at the nominated climb speed, select the climb attitude.

Straight and level flight should be regained at the starting altitude, and the reference point or heading regained if necessary.

The student should expect an altitude loss of less than 50 feet, and reducing to zero when recovering at onset, with practise and early recognition.

Airborne Sequence

On the Ground

The student should be able to get the aeroplane ready for flight, and carry out the checklists, while still working towards learning the checks.

The Exercise

The student should now be able to take you to the training area and position the aeroplane within the training area at a suitable altitude, completing the necessary checks, and carrying out the basic stall and recovery. Your assistance is given only as required.

To refamiliarise the student with the stall nose attitude or airspeed, the student should start by carrying out at least two basic stalls, with recovery at stall and then at onset with minimum height loss.

> This exercise is leading the student to the realisation that in the approach configuration the attitude at the stall is noticeably lower than might be expected, and that throughout a normal approach the aeroplane's nose is well below the horizon. The emphasis is on the observed attitude at the stall more than the indicated airspeed although the lower airspeed should be noted.

Demonstrate a stall with some power and no flap, and recover. Point out the nose-high attitude and lower airspeed. The more power used, the more noticeable the increased nose-high attitude and the lower the stall speed. At high power settings with no flap, the entry can be considerably prolonged (unless altitude is gained). Therefore, normally somewhere between 1500 and 2000 rpm should be sufficient (refer CFI).

Then demonstrate a stall with no power and full flap, and recover. Point out the nose-low attitude, often similar to the straight and level attitude, the lower airspeed, and with flap how quickly airspeed reduces.

During the demonstrations or follow-through of the stall, with power only and then flap only, you must ensure that a constant altitude is maintained during the entry, as any tendency to gain altitude will affect the nose attitude observed at the stall.

Once the difference in attitude and airspeed at the stall, as a result of the aeroplane's configuration, has been observed introduce the effects of a combination of power and flap on the attitude and airspeed. Use the approach configuration for this.

After the student has experienced the stall symptoms and recovery technique, move on to recovery at onset. Outside the training environment the student needs to be able to recognise the symptoms of the approaching stall and recover before the aeroplane stalls.

Rather than nominate the stall warning as the 'symptom' at which to recover, ask the student to tell you the symptoms they expect to see and in which order, and then say them as they occur. The stall warning will typically activate at 1.2 V_S which is too far above the stall to effectively demonstrate and note the symptoms clearly. The student needs to recognise the feel of the aeroplane when near the stall.

If the stall warning is not operative, the buffet, if recognisable in the aeroplane used, may be used as the symptom at which recovery is initiated. The only disadvantage of this is that, with power on, the buffet may be very difficult to detect.

During the entry and recovery, you should emphasis eyes outside on attitude and keeping straight using the reference point, for it will be shown in the wing-drop stall that, if the aeroplane is permitted to yaw, one wing will stall before the other. In addition, smoothly raising the nose to the horizon and countering the effects of raising flap should be emphasised.

The student should be able to return you to the aerodrome, and make most of the radio calls required.

After Flight

If this lesson is given after solo and circuit consolidation, it is recommended the next lesson be *Wing-Drop Stalling*.

Otherwise, the next lessons will be in the circuit, where the student will be learning how to fly a circuit and land the aeroplane. They will be drawing on all of the skills they have learnt so far. Ask the student to read any notes on the circuit lessons.

Maximum Rate Turns

To achieve the maximum rate of turn, the greatest possible force toward the centre of the turn is required. This is achieved by inclining the lift vector as far as possible. Therefore, maximum C_L, achieved at the maximum angle of attack, is combined with the maximum angle of bank.

The maximum rate of turn occurs when the aeroplane is changing direction at the highest possible rate, ie, maximum degrees turned through in minimum time. In most light two-seat training aeroplanes the angle of bank during this exercise is approximately 60 degrees.

A minimum radius turn achieves a change of direction using less space and is usually done at a lower speed.

This briefing discusses the factors that limit the rate of turn, not only for the aeroplane being flown, but also for fixed-wing aeroplanes in general, so that the principles may be applied to subsequent types.

For the purposes of collision avoidance, in response to an emergency situation, the turn entry requires a rapid roll in. However, the roll out is smoothly executed because the emergency is over. It should be noted, however, that the need to do a maximum rate turn suggests earlier poor decision making.

As an exercise, the rapid-roll in and smooth roll out provide excellent coordination practise, because two different rates of rudder and elevator application are required to match the rate of roll. Logically these turns would not be continued past 180 degrees in the case of collision avoidance.

Objective

To carry out a balanced, maximum rate, level turn using full power.

Principles of Flight

The limitations of turning while using the highest possible angle of attack and at the highest possible angle of bank are discussed.

Briefly revise the forces in the turn and the increasing load factor with increasing angle of bank.

Maximum Lift

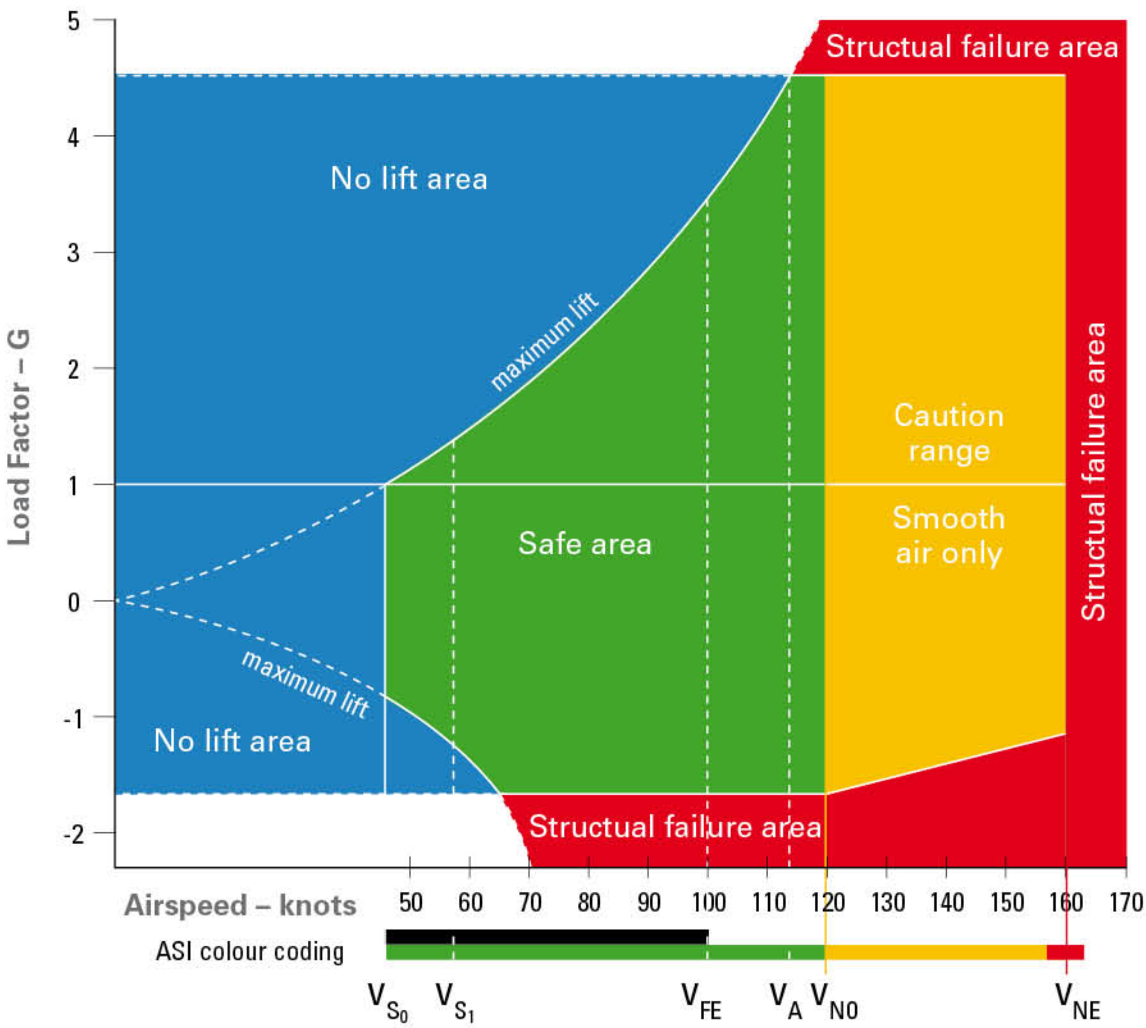
Lift varies with angle of attack and airspeed. The highest useful angle of attack is just before the critical angle, about 15 degrees. At this high angle of attack, maximum C_L, considerable drag is produced, and if the aeroplane stalls, or the buffet is reached, the drag will increase dramatically. Ideally, sufficient backpressure should be applied to activate the stall warning (if it is operating) on its first note. Alternatively, the very edge of the buffet will need to be used as a guide to maximum C_L.

> There are two considerations here for discussion with your supervisor. Firstly, flying the aeroplane with the stall warning activated and not carrying out the stall recovery could be considered negative transfer. On the other hand, considerable situational awareness is required to purposely operate the aeroplane in this regime.

Secondly, you should be aware that experiencing any buffet will reduce the rate of turn because of its effects on drag and L/D ratio. Therefore, if the stall warning is not operating, and the lightest of buffets is used to determine maximum C_L, performance is degraded, and the aeroplane will not be turning at its maximum rate.

Airspeed

Figure 1



Definitions

V_A	Design manoeuvre	V_{S_0}	Stall speed – flaps extended
V_{NO}	Normal operating speed	V_{S_1}	Stall speed – clean
V_{NE}	Never exceed speed	V_{FE}	Maximum speed with flap extended

The speed we are particularly interested in, with regard to maximum rate turns, is V_A.

V_A is the maximum speed at which the pilot can make abrupt and extreme control movements and not overstress the aeroplane's structures. Above V_A and the aeroplane can be overstressed before it stalls. Below V_A the aeroplane will stall before it is overstressed.

This is a particularly important consideration if the nose is allowed to drop during steep turns, and the pilot pulls back harder on the control column to regain the height. The correct recovery technique is to reduce the angle of bank before increasing the back pressure.

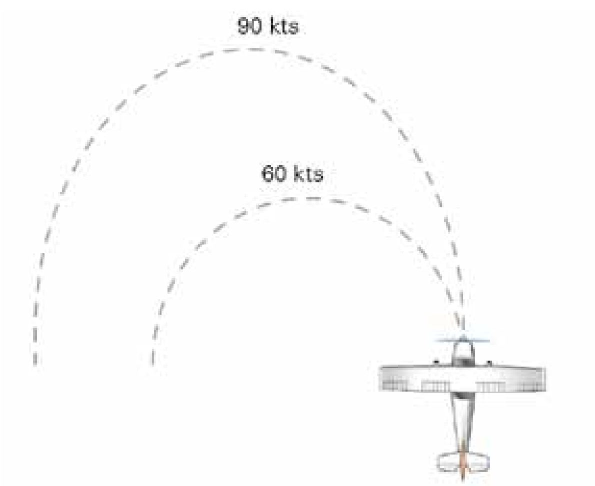
V_A is determined by multiplying the basic stall speed by the square root of the maximum load factor. If the aeroplane has a basic stall speed of 50 knots and a maximum flight load factor of 4, the V_A speed would be 100 knots ($50 \times \sqrt{4} = 100$). Practically, the speed will be found in the Flight Manual.

V_A is affected by the aeroplane's weight and reduces as weight reduces. This is because a heavier aeroplane will take longer to respond to a full control deflection than a lighter aeroplane. The quick response of the lighter aeroplane results in higher loading. Therefore, as the weight of the aeroplane is reduced, the speed at which full and abrupt control movements can be made is also reduced (refer Flight Manual).

Rate of turn is the rate of change of direction, ie, how many degrees are turned through in a specific time, usually a minute.

Radius of turn is the size of the arc made by the aeroplane as it turns.

Figure 2



A low speed means a higher rate of turn; a higher forward speed means a lower rate of turn.

A high speed allows you to generate more lift and therefore use an increased angle of bank, but the high airspeed means the radius of the turn (how many nautical miles it takes to make the turn) is high and therefore the rate will be lower.

To turn at maximum rate we need maximum centripetal force and maximum lift. The increased angle of attack means increased drag, so full power is used. As rate of turn is proportional to velocity the limiting factor in a maximum rate turn is power.

If speed is below V_A at entry, full power can be used before rolling into the turn. If speed is at V_A full power can be applied in conjunction with the roll. When speed is above V_A, roll into the turn first and then apply power, so as not to exceed V_A.

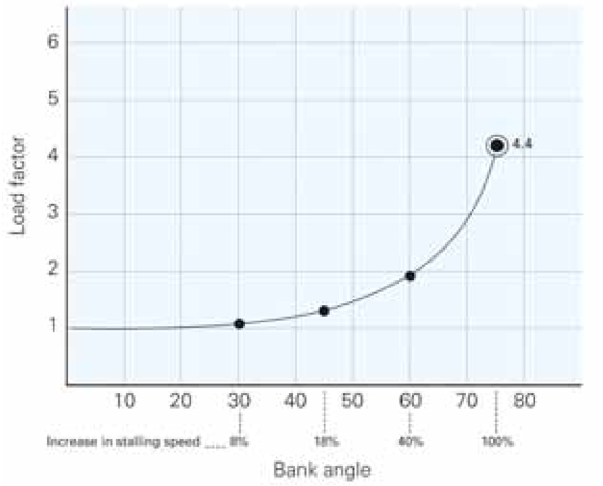
To make a maximum rate turn you need to turn at the highest angle of bank that can be sustained at the lowest possible airspeed – just above V_S – this is why the stall warning is used to indicate maximum rate.

Angle of Bank

Somewhere between wings level and 90 degrees there is a practical limit to the angle of bank that can be used, as the aeroplane cannot be turned at 90 degrees angle of bank because there would be no vertical component to balance the weight, no matter how much lift was produced.

Structural Limit

Figure 3



This diagram shows the relationship of load factor to increasing angle of bank. The structural load limit for the aeroplane will determine the maximum angle of bank that could be used without structural failure. Most light training aeroplanes have positive structural load limits of +3.8 G in the normal category and +4.4 G in the utility category. It can be seen that this limit is reached between 70 and 75 degrees angle of bank. Therefore, the average light training aeroplane cannot turn at angles of bank greater than about 75 degrees without causing structural damage.

Angle of Bank Limit

From the graph, state the limiting angle of bank you will be using in your aeroplane.

> The steep turn, generally approved as a semi-aerobatic manoeuvre in most light training aeroplane's Flight Manuals, involves an angle of bank of about 60 degrees.

> Those semi-aerobatic manoeuvres approved in the Flight Manual may be carried out only while operating in the utility category.
>
> The difference between the normal and utility category is determined by the position of the C of G (refer Flight Manual). For most light training aeroplanes there is no difference in the C of G range, only a restriction that the baggage compartment must be empty for the aeroplane to be in the utility or semi-aerobatic category.

As was seen in the *Steep Turns* lesson, an increase in angle of bank requires an increase in the angle of attack to increase the lift, which in turn increases the drag, adversely affecting the L/D ratio, resulting in a decrease in airspeed.

Power is used to oppose the increase in drag. However, since power available is limited, the airspeed will reduce as the angle of bank increases.

The stalling speed increases as the square root of the load factor. With a basic stall speed of 50 knots, 75 degrees angle of bank increases the stall speed to approximately 100 knots. Even if there were no drag increase this would be about the normal cruise speed.

Therefore, the maximum angle of bank will also be limited by the amount of power available to overcome the increasing drag. For most light training aeroplanes, this is the limiting factor at about 60 degrees angle of bank. With the amount of power available, the highest possible speed that can be maintained is a stall speed well below V_A (about a 40% increase over the basic stall speed). However, it is not necessarily the only limiting factor, as a light twin-engine aeroplane or high performance single may well have sufficient power to combat the increased drag and maintain or exceed V_A. Commonly, in this case the aeroplane's structural limitations limit the maximum angle of bank.

Limitations of the Pilot

The only other limitation on achieving the maximum rate of turn is that of the pilot.

Considerations

Entry Speed above V_A

If the airspeed is above V_A for the weight, the entry must employ a smooth roll in. Generally, the application of power is delayed until the aeroplane decelerates to V_A. Then, power is applied as required to counter the increasing drag in an effort to maintain V_A (for the weight).

Entry Speed Well Below V_A or Normal Cruise

This would be any airspeed around the stall speed for 60 degrees angle of bank (V_S plus about 40%, eg, 50 knots plus 40% = 70 knots).

In this case, power should lead the roll-in or be applied rapidly but smoothly as soon as the roll-in is started.

Airmanship

The aeroplane's V_A speeds at all up weight and empty (if given in the Flight Manual) are most relevant to this exercise. A stall, or the use of abrupt control movements to initiate the entry, must be avoided above this speed.

Any organisation-imposed minimum altitude for the conduct of maximum rate turns should be stated (refer CFI).

Aeroplane Management

For light training aeroplanes, the increase in drag will require that maximum power is used – do not exceed the rpm limit.

The aeroplane's C of G limitations for the normal and utility categories may be revised.

Human Factors

Disorientation is minimised by choosing a very prominent reference point. In addition, regular practise at conducting the turn through 360 and 180 degrees (in later lessons, refer CFI) will also improve orientation.

With an increasing positive load factor or G, the heart has more difficulty pumping blood to the brain. Because the eyes are very sensitive to blood flow, the effects on vision of increasing G are noted.

During the maximum rate turn, in most light training aeroplanes, the increased G would not be expected to exceed +2 G.

Spots before the eyes form at about +3 G, with grey-out occurring at about +4 to +5 G, and blackout at about +6 G.

These effects vary between individuals and are affected by physical fitness, regular exposure and anti-G manoeuvres or devices, for example, straining, or the use of a G-suit.

Air Exercise

The air exercise discusses entering, maintaining and exiting the level maximum rate turn.

Entry

A reference altitude and very prominent reference point are chosen and the lookout completed.

A check is made to establish where the aeroplane's speed is, in relation to V_A for the aeroplane's weight. For most light training aeroplanes the airspeed will be about 10 to 20 knots below V_A when entering the maximum rate turn from level flight.

Assuming the airspeed is below V_A, full power is applied and the aeroplane is rolled rapidly, but smoothly, into the turn with aileron, and balance maintained by applying rudder in the same direction as aileron. As large deflections of aileron are used, more rudder than usual will be required to overcome adverse yaw.

Backpressure is increased on the control column to keep the nose attitude level relative to the horizon, pulling smoothly to the stall warning (or light buffet) to maximise lift.

When the stall warning is activated, maintain backpressure and hold the angle of bank to maintain height. This will be recognised through attitude and confirmed through instruments, a slight check will be required to overcome inertia in roll and rudder pressure will need to be reduced to maintain balance.

In the entry from straight and level, excess airspeed may permit a higher angle of bank to be selected initially, especially if the roll is very rapid. However, as the airspeed reduces, the angle of bank will need to be reduced to C_{Lmax} to maintain altitude. Therefore, for the purposes of coordination, it may be beneficial to roll rapidly but smoothly, so that the airspeed reduction coincides with C_{Lmax} and with the application of full power (refer CFI).

If the very rapid roll-in is preferred (for a true avoidance turn rather than a coordination exercise), the initial angle of bank must not exceed the angle of bank at which the structural limits are reached.

Maintaining the Turn

Maintaining the turn incorporates the **LAI** scan. Emphasise lookout, and maintain the attitude for C_{Lmax} and level flight.

The effect of side-by-side seating on attitude recognition should be discussed, preferably with the aid of an attitude window.

During the turn, maintain the maximum amount of lift for the airspeed by maintaining the first note of the stall warning with backpressure.

As the lift cannot be increased any further, the altitude is maintained with angle of bank. Therefore, with the stall warning activated, if altitude is being gained or lost, alter the angle of bank.

> Angle of bank can only be increased to the maximum coinciding with the aeroplane's structural limit. An alteration of ±5 degrees angle of bank should be sufficient to maintain altitude.

Exit

Look into the turn for traffic and the reference point, and allow for inertia by anticipating about 30 degrees before (half the angle of bank), and roll out smoothly.

Theoretically the emergency is over; anticipating by half the bank angle will require a reduced rate of rudder application compared to the entry. This provides practise in coordination.

Smoothly roll wings level with aileron, balance with rudder in the same direction to overcome adverse yaw, and relax the backpressure to re-select the level attitude. Most low-powered training aeroplanes require the reduction of power to be delayed on exiting the maximum rate turn.

Therefore, through ________ knots (normally the same airspeed used in entering straight and level from the climb) reduce power to cruise rpm.

Airborne Sequence

The Exercise

Once the student has taken you to the training area you should start the exercise with medium level turns, making sure the student notices the attitude. Follow with practise of the steep turns from the last lesson, also noting the attitudes required.

Then you take over and demonstrate, with patter, the maximum rate turn in one direction, followed by student practise with you talking them through, and then the student has the opportunity to practise. Then the other direction.

During one demonstration, the student's attention should be drawn to the rate of turn by looking at the rate at which the nose progresses around the horizon. If the aeroplane is brought to the buffet or stall, the rate of turn will noticeably decrease. Inclusion of this demonstration is at the CFI's discretion.

The majority of the lesson is taken up with student practise, as it may take some time for them to reach an acceptable standard.

After Flight

Be clear with the student about whether you are happy for them to practise this exercise solo. There will be plenty of opportunity to practise these in dual flights.

Wing-Drop Stalling

This briefing discusses the reasons why one wing may stall before the other, resulting in the stall commonly known as a wing-drop stall, as well as the consequences and correct recovery technique.

Stalling in the turn may produce the same consequences and requires the same recovery technique. If the turn is to be maintained rather than level flight regained, only the entry and the last item in the recovery are different. Therefore, stalling in the turn may be incorporated within this briefing. However, at the PPL level, the CFI may prefer a separate briefing for stalling in the turn (refer CFI).

By wing-drop stall we mean a stall where one wing stalls before the other. The wing that reaches the critical angle first (at about 15 degrees) will stall first, losing lift and causing a roll at the stall. This often happens because of poor pilot technique where the aeroplane is out of balance at the stall, or aileron is being used.

Once the wing stalls, aileron will not stop the roll, it will worsen the situation. If the wing-drop is not promptly recovered, a spin may develop. The purpose of this exercise is to stop the natural tendency to pick the wing up with aileron and to practise the correct method of recovery.

Objectives

To revise stalling with power and flap.

To carry out a stall from straight and level flight (and the turn) recovering from a wing drop with minimum altitude loss.

Principles of Flight

Revise the cause of the stall – exceeding the critical angle of attack, regardless of the observed airspeed.

There are many reasons why aileron may be being used at the stall.

Turning

During the turn, angle of bank is maintained with aileron.

Out of Balance

If the aeroplane is permitted to yaw at or near the stall there will be a tendency for the aeroplane to roll (further effect of rudder), which will increase the angle of attack on the down-going wing. In addition, if an attempt is made to maintain wings level with aileron, the down-going aileron will increase the mean angle of attack on that wing. This usually results in that wing reaching the critical angle first.

Ice or Damage

If ice forms on the wings, or one wing is damaged, by bird strike or 'hangar rash', the smooth airflow over the wing will be disturbed, and may break away sooner than the flow over the other wing – resulting in that wing stalling earlier than the other.

Weight Imbalance

If all the passengers or fuel are on one side of the aeroplane, some aileron will be required to maintain wings level.

Turbulence

When operating near the critical angle, a gust or turbulence may result in aileron being used to maintain wings level, or the modified airflow as a result of the gust may cause one wing to exceed the critical angle.

Rigging

If the wings were fitted to the aeroplane at slightly different angles of incidence, or the flaps have been rigged incorrectly, when approaching the stall, one wing would reach the critical angle before the other.

Power

Slipstream modifies the angle of attack on each wing because of its rotational nature. In clockwise rotating engines (as viewed by the pilot), the angle of attack is decreased on the starboard wing and increased on the port. Therefore, the aeroplane may drop a wing more readily when partial power is used.

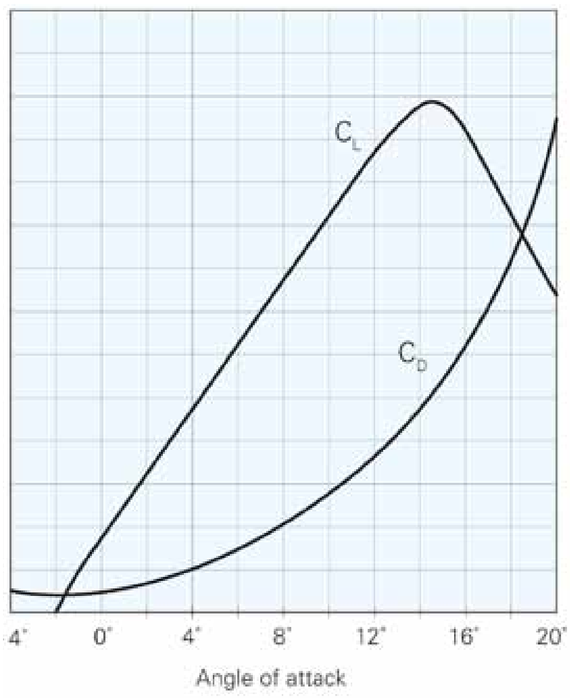
Flaps

It is possible for flap to extend at slightly different angles. In addition, when flap is extended the aeroplane is less laterally stable, as the centres of pressure on each wing move in toward the wing root. This increases the tendency for the aeroplane to be easily disturbed in roll, which may cause one wing to exceed the critical angle. However, there is also a greater need to use aileron to maintain wings level in this configuration. Therefore, the aeroplane may drop a wing more readily when flap is selected.

The consequences of one wing exceeding the critical angle before the other are discussed.

The wing that stalls first has a reduction in lift, causing roll. The roll increases the angle of attack on the down-going wing and may delay the stall of the up-going wing. Increasing the angle of attack past the critical angle will result in a decrease in lift but a substantial increase in drag (use C_L and C_D against angle of attack graph).

Figure 1



The increase in drag yaws the aeroplane toward the down-going wing, which may further delay the stall of the up-going wing as a result of increased airspeed. This process, where yaw causes roll, which causes yaw, is known as *autorotation*.

By using aileron to stop the roll (a natural tendency), the mean angle of attack increases on the down-going wing. The lift continues to decrease with an increase in angle of attack (past the critical angle), while the drag continues to increase rapidly with any small increase in angle of attack. Show the effect of aileron on the C_L and C_D curves on the graph.

The use of aileron adversely affects the roll and favours autorotation. This is the reason for maintaining ailerons neutral in the initial stall recovery.

The correct method of stopping autorotation is to break the yaw-roll-yaw cycle, and since aileron cannot be used effectively to stop the roll, rudder is used to prevent further yaw. The nose is lowered simultaneously (backpressure relaxed) with the application of rudder, and this will stop the roll immediately.

Airmanship

Revise the requirement to carry out all stalling practise in a safe environment

Revise the **HASELL** and **HELL** checks.

Emphasise symptom recognition for avoidance.

The student should strive to improve situational awareness by integrating the attitude and airspeed with the aeroplane's configuration, phase of flight and symptoms of the approaching stall.

Aeroplane Management

As the objective is to carry out a stall with a wing-drop, a configuration most likely to induce a wing-drop is used, commonly 1700 rpm and full flap is used. The combination of these two factors will often lead to a wing-drop occurring at the stall.

Some aeroplane types, eg, PA38, will perform good wing-drop stalls in the basic configuration (power idle, flap up) (Refer CFI).

The use of carburettor heat may require revision.

Revise the airspeed and rpm limits.

Human Factors

Overlearning is used to improve information processing to recognise the situation and consciously ignore the roll while responding with the correct recovery technique.

Air Exercise

Start by revising stalling in various configurations. This will help make the student more comfortable before tackling the wing-drop stalls.

When satisfied that the student is ready to progress, you should begin the exercise with the demonstration and patter of a wing-drop stall (see "Airborne Sequence").

Entry

HASELL checks are completed, and a prominent outside reference point (backed by the DI) on which to keep straight is nominated.

From level flight, carburettor heat is selected HOT and the power smoothly reduced to ________ rpm. As the nose will want to yaw and pitch down, keep straight with rudder and hold the altitude with increasing backpressure.

Below ________ knots (in the white arc) select flap gradually, if applicable to aeroplane type. During the application of flap, check forward to prevent any gain in altitude due to the increase in lift, before reapplying backpressure to maintain altitude.

Through ________ knots, or when the aural stall warning is heard, select carburettor heat COLD, as full power will shortly be applied.

At the stall, altitude is lost, the nose pitches down, and one wing may drop.

If the aeroplane is reluctant to drop a wing at the stall, alter the power and flap combination (refer CFI) and relax rudder pressure to simulate the pilot's failure to maintain directional control. Alternatively, a gentle turn may be required (5 degrees angle of bank).

> There is nothing underhand about these techniques, as permitting the aeroplane to yaw or stall in the turn are possible causes of a wing-drop stall.

In addition, avoid an accelerated stall (by zooming the entry) which may produce a rapid roll. The student should see a rapid stall at some point in their training, but the first stall is not the time for it. If a pronounced wing-drop occurs, the application of full power may need to be delayed to avoid exceeding flap limiting speeds, or on the Piper Tomahawk, V_{NE}.

Recovery

The recovery may be discussed in three parts, but the ultimate objective is to coordinate all three actions.

To unstall

Keep the ailerons neutral.

At the same time

Simultaneously decrease the back pressure/check forward and apply sufficient appropriate rudder to prevent further yaw.

Excessive rudder should not be applied (to level the wings through the secondary effect of rudder) as this may cause a stall and flick manoeuvre in the opposite direction to the initial roll (wing drop).

To minimise the altitude loss

Full power is smoothly but positively applied. At the same time, level the wings with aileron (as the aeroplane is now unstalled), centralise the rudder, and raise the nose smoothly to the horizon to arrest the sink and minimise the altitude loss.

Hold the nose at the level attitude, and reduce the flap setting (as appropriate to aeroplane type) immediately.

At a safe height, safe airspeed and with a positive rate of climb – raise remaining flap (counter the pitch change). The aeroplane will continue to accelerate, and at the nominated climb speed select the climb attitude.

Straight and level flight should be regained at the starting altitude and the reference point or heading regained.

Airborne Sequence

The Exercise

The student should be capable of positioning the aeroplane within the training area at a suitable altitude, completing the necessary checks, and possibly carrying out the advanced stall and recovery. Instructor assistance is given only as required.

For the purposes of demonstration and patter, the recovery may be broken down into three separate phases (refer CFI). Alternatively the three phases may be condensed into two or even one phase, depending on your assessment of the student's ability.

> It is recommended that all stalling exercises finish with a reminder that outside of the training environment the student would recover at the onset of the stall at the latest.

At the completion of this exercise, there may be time to practise *maximum rate turns*, if previously covered.

Short-Field Takeoff & Landing

Developing the student's decision-making processes in relation to taking off or landing on runways of minimal length provides a real challenge for the professional flight instructor.

This briefing uses the performance data provided in the Flight Manual to operate the aeroplane at its safe and legal limit.

A short (or minimal) field is one where the runway length is shorter than that normally available for the conditions, but is still sufficient for takeoff and/or landing. It is not one that is too short. Nor is it one where the runway length is unknown.

When a runway group number is not available, or is available but less than the aeroplane's group number, reference must be made to the Flight Manual to ensure there is adequate runway length available under the existing conditions. As a rule, if doubt exists under any circumstances, refer to the Flight Manual.

Performance ('P') charts, where available, are a valuable source of takeoff performance information. Manufacturer's graphs in Flight Manuals should be used in the absence of P-charts. If using the latter, it is recommended that pilots apply the appropriate surface correction factors from Advisory Circular 91-3 *Aeroplane performance under Part 91*.

An approach to a field where the runway length is unknown, or is known to be too short, may occur during the precautionary landing. This is an emergency procedure, but the approach technique is the same as for a short-field landing.

The *Takeoff and Landing Performance* Gap booklet is a useful reference for this lesson.

Objectives

To ensure, by calculation, that there is adequate runway length for takeoff and landing in accordance with the aeroplane's performance data.

To apply sound decision making principles before adopting the recommended procedure for takeoff or approach for a runway of minimal length.

To operate the aeroplane in accordance with the manufacturer's recommended short-field techniques in order to obtain the best possible performance.

Takeoff Considerations

Temperature

The most important effect of temperature is to change density. An increase in temperature will result in a decrease in density. Since the expected engine performance is based on a standard temperature of 15 degrees Celsius at sea level, a correction will need to be made for the actual or ambient temperature.

If you are in the aeroplane, on the field of takeoff, the aeroplane's outside air temperature (OAT) gauge gives ambient temperature. Otherwise, this information is provided in a METAR if available.

Density

Density also affects the indicated airspeed (IAS). As density decreases, IAS decreases. Therefore, as the density decreases, the aeroplane's actual speed (TAS) will need to be increased to achieve the same IAS for any given rotate IAS. This will increase the length of the takeoff roll, but the effects of density on engine performance are far more critical.

Pressure Altitude

The calculation of pressure altitude (PA) is vital for takeoff, as this corrects the airfield elevation under the existing conditions to an elevation within the standard atmosphere, and the standard atmosphere is what the expected engine performance is based on.

If you're on the aerodrome of takeoff and in the aeroplane, you can simply set 1013 hPa on the altimeter sub-scale and read off the pressure altitude. However, if you're not on the aerodrome of takeoff, you need to know the airfield's QNH (from the METAR) and elevation (from the aerodrome chart) in order to calculate pressure altitude.

Aeroplane Weight

The aeroplane's weight is derived from the weight and balance calculations and will directly affect the takeoff and climb performance.

Runway Surface

The takeoff roll is reduced on a firm or sealed surface compared to a soft or grass surface, as there is less surface friction. Since the takeoff performance figures provided in the Flight Manual must be calculated using known parameters, a grass surface is defined as short dry grass. Long or wet grass will markedly increase the takeoff distance.

Slope

An up-slope increases the takeoff distance and a down-slope reduces it. The slope of a runway, as a percentage, is given in the operational data on the aerodrome chart in the AIP *Vol 4*.

Headwind Component

When the wind is at an angle to the runway in use, the headwind component will need to be calculated. Use the chart provided in the Flight Manual.

Wind

If strong or gusty winds are present, there is always the possibility of windshear in the climb-out. If a decrease in wind speed is suddenly encountered during takeoff, additional power will not be available to arrest the sink. Therefore, the rotate speed (V_R) and the takeoff safety speed (V_{TOSS}) are increased by an appropriate amount to counter the possible effects of windshear.

For steady wind speeds of 10 knots or less, use the book figures.

For winds above 10 knots, this speed is progressively increased (refer CFI and Flight Manual).

Whenever the rotate, takeoff safety speed or best-angle-of-climb speed needs to be increased because of the conditions, think about whether to continue with the exercise.

Calculation

The calculation of the required takeoff or landing distance should be a relatively simple process that encourages its regular use and the application of ADM principles.

> The use of performance graphs should have been covered in previous lessons.

Collect all the necessary information and consult the Flight Manual to determine the required takeoff distance.

The takeoff performance graphs in most light aircraft Flight Manuals provide only one weight, All Up Weight (AUW). This is because the range of weights for takeoff or landing is insignificant and, since AUW cannot be exceeded, provides a safety margin at lower weights. Larger aircraft Flight Manuals provide two or more weights. Where only an AUW is given, lesser weights cannot be extrapolated. AUW must be used regardless of the aeroplane's actual weight.

Using either P-charts where available, or the Flight Manual performance data, plus AC91-3 surface correction factors, calculate the distance for takeoff under the existing conditions. Compare this with the distance available, as given in the aerodrome chart's operational data, or as determined by other means.

If the takeoff distance available is less than the takeoff distance required – walk away!

If the takeoff distance available is equal to or slightly more than the takeoff distance required – think carefully!

Double-check your calculations. Have all factors been properly taken into account?

Remember that an accurately performed short-field takeoff will be required in order to ensure that the performance data contained in the Flight Manual is met.

Takeoff performance figures are based on shiny new engines and propellers – how does this aeroplane compare? Is the surface short dry grass or a bit long? How important is it that a takeoff be conducted now – under these conditions – and how will the conditions be affected by a delay?

The calculated takeoff distance to a height of 50 feet assumes full power is applied before brake release and that the stated flap setting is used. The distance required for takeoff includes the ground roll and the distance travelled over the ground to reach a height of 50 feet at the takeoff safety speed (V_{TOSS}) which is based on the aeroplane's stall speed and therefore varies with the weight.

> The takeoff safety speed (V_{TOSS}) is the speed to be achieved after liftoff and before a climb above 50 feet. Although, for most light training aeroplanes, it is commonly the same speed as the best angle of climb speed (V_X), however, this speed does not usually include the use of flap (refer to Flight Manual for manufacturer's recommended procedures and/or CFI).

Some Flight Manuals have two takeoff charts, one without flap and another with flap. The use of flap is often recommended for takeoff from a soft field or where obstacles are present in the climb-out path (refer Flight Manual). This is because the increase in lift provided by flap allows the aeroplane to lift off sooner at a lower airspeed, thereby minimising the ground roll and surface friction.

Commonly, a lower takeoff safety speed (V_{TOSS}) is nominated when flap is used. This is because flap lowers the stalling speed, making a lower takeoff speed possible. In addition, the decreased groundspeed resulting from the lower climb airspeed allows a similar angle to the best-angle, to be achieved.

Takeoff distance calculations should be based on the appropriate performance figures, depending on whether flap is recommended for takeoff or not.

Unless all of these are applied with, calculation of the required takeoff distance is negated.

As this exercise is not generally carried out from minimal length fields, remember to advise students that such conditions are being simulated.

Do not allow the student to round off the rotate or takeoff safety speed to the nearest mark on the airspeed indicator, for example, takeoff safety speed 54 knots, which is "near enough to 55 knots". This exercise requires accurate flying skills, and these only come from practise. Although one knot may make no appreciable difference to the aeroplane's performance, this practise will ultimately make a considerable difference to the student's attitude towards performance.

Landing Considerations

Aerodrome Elevation or Pressure Altitude

Because of the low power setting used on the approach, aerodrome elevation is used when calculating landing distance and the effects of pressure altitude ignored. However, an increase in altitude will result in a decrease in the air density. As density decreases, IAS decreases and the aeroplane's actual speed (TAS) will be increased for any given indicated threshold crossing speed. Therefore, the aerodrome height above sea level will affect the length of the landing roll, and pressure altitude may be used for more accurate calculations (refer Flight Manual and CFI).

Weight

The aeroplane's weight affects inertia and therefore the stopping distance.

Runway Surface

The landing roll is reduced on a firm dry surface compared with a grass or wet surface because of the improved braking action. Remember that grass is defined as short dry grass.

Slope

An up-slope decreases the landing distance, and a down-slope increases it. Slope is given in the aerodrome operational data.

Headwind Component

When the wind is at an angle to the runway in use, the headwind component will need to be calculated. Use the chart provided in the Flight Manual.

Wind

If strong or gusty winds are present, there is always the possibility of windshear on the approach. The approach and target threshold speeds (V_{TT}) are increased by an appropriate amount to counter the possible effects of windshear.

For steady wind speeds of 10 knots or less, use the book figures.

For winds above 10 knots, this speed is progressively increased (refer CFI and Flight Manual).

Whenever the approach or threshold speed needs to be modified, consider whether to continue with the exercise. The answer may be affected by the excess runway available over that required.

Calculating the Landing Distance

With the necessary information collected, the Flight Manual is consulted in order to determine the landing distance required.

The calculated distance for landing under the existing conditions, is compared to that available, which is given in the aerodrome chart's operational data.

If the landing distance available is less than the landing distance required – walk or fly away!

If the landing distance available is equal to or slightly more than the landing distance required – think carefully!

Double-check your calculations. Have all factors been properly taken into account?

Remember that an accurately performed short-field landing will be required in order to ensure that the performance data contained in the Flight Manual is met.

The Flight Manual for each aeroplane type states the maximum speed for crossing the threshold, and the flap setting to be used.

The required landing distance in the Flight Manual is calculated from a height of 50 feet above the threshold in the stated configuration. That is, the distance required for landing includes the distance to touch down from 50 feet over the threshold and the ground roll to a full stop.

Crossing the threshold higher than 50 feet, using less than full flap, or crossing the threshold at a higher airspeed, will increase the landing distance.

Airmanship

Pilots should consider their own ability before attempting a takeoff from or landing onto a runway of minimum length.

The decision-making considerations of a normal takeoff apply; but additional decision making is required in relation to a strong or gusty wind and EFATO.

The possibility of EFATO during a short-field takeoff requires an amendment to the takeoff safety brief. Rather than simply lower the nose, as a result of the very high nose attitude and the low airspeed during the initial climb out, the brief is modified to emphasise immediately and positively lowering the nose.

Discuss the decision making required when deciding to go or to abort the takeoff or landing.

Aeroplane Management

Full power before brake release is confirmed by checking that the required static rpm is being achieved. This figure (often stated as a range, eg, 2280 to 2380 rpm) is in the Flight Manual.

If static rpm is not achieved, simple ADM should result in a logical sequence of: full power is not achieved therefore, maximum performance cannot be achieved, and therefore, the takeoff must not be attempted.

Have an aircraft engineer check out and clear the problem before further flight.

There are a few reasons why static rpm may not be achieved, and consideration of these requires the application of a higher level of ADM.

Icing
Check for carburettor ice and that the carburettor heat control is set to COLD. If this cures the problem, continue with the takeoff.

Instrument error
Is this rpm normal for this aeroplane? Has this rpm reading been confirmed by the engineers as indicative of full power in this aeroplane? (If so, why is this state of affairs acceptable? Refer CFI).

Propeller
Is the propeller in good condition, and is it the same propeller installed by the manufacturer, on which the static rpm is based. Or has it been replaced with a propeller of coarser pitch?

These last two possibilities cannot be confirmed while sitting at the holding point; taxi back to the start-up area and consult an aircraft engineer.

Human Factors
Vision may be affected by the high nose attitude on takeoff and terrain ahead may produce a false horizon. Therefore, regular cross-reference to instruments is emphasised.

During an approach to land, perception may be influenced by the visual cues of surrounding terrain, a false horizon or runway length and width. Therefore, regular cross-reference to instruments is emphasised.

Air Exercise

Takeoff
While holding the aeroplane on the brakes (nosewheel straight) with elevator neutral, full power is applied. Static rpm and temperatures and pressures are checked for normal indications.

> Good aviation practice dictates that all takeoffs must be made using full runway length.

Ensure a clean brake release, and as soon as the aeroplane starts to move, take the weight off the nosewheel with elevator, to reduce surface friction, and check for normal acceleration.

The nosewheel should be held on the ground until the rotate speed (V_R) is achieved. This will require an adjustment to backpressure as the airspeed increases and the elevator becomes more effective. Rotating early only increases the aerodynamic drag and prolongs the takeoff roll.

As V_R is reached, smoothly rotate the aeroplane and lift off (do not 'haul' into the air). Lower the nose and allow the aeroplane to accelerate to the takeoff safety speed (V_{TOSS}). This generally requires only a small decrease in backpressure rather than a noticeable check forward.

On reaching V_{TOSS} the attitude is adjusted and held. As a result of the high power setting and low airspeed, more rudder than normal will be required to keep straight on the reference point.

At a safe height (assuming that any obstacles have been cleared), accelerate to best rate of climb (V_Y) or the normal recommended climb speed (refer CFI). Check the aeroplane is in balance.

Before raising flap (if used), there are three criteria that must always be met: safe height, safe airspeed, and a positive rate of climb. When these conditions have been met, raise flap and counter the pitch change. Allow acceleration to continue, and upon reaching the climb speed required (best rate or normal), trim to maintain the appropriate attitude.

Landing
During the downwind leg the conditions used for the approach and threshold speeds are confirmed and an aim point chosen. The aim point should be as close to the threshold as is safe (consider obstacles on approach). If the exercise is being flown onto a marked runway, a point just short of the numbers painted on the surface is a good choice as an aim point.

> The selection of this aiming point should not be confused with the club competition of spot landings, where the objective is to land on a spot, usually well into the runway. Although the same approach technique is employed, nominating an aiming point well into a field of minimal length would negate the landing distance calculations.

The procedure to achieve the optimum aeroplane performance for landing as stated in the Flight Manual is used. The stated performance figures are based on the aeroplane being operated at its optimum.

The turn onto base is carried out in the normal manner but delayed slightly by extending the downwind leg to ensure some power must be used throughout the entire approach.

> Because this type of approach employs a low threshold speed, a heavy aeroplane with considerable inertia may not have sufficient elevator effectiveness to initiate the flare even though full elevator deflection may be used. Using power throughout the approach gives total control over the rate of descent and additional elevator effectiveness during the flare.

The approach path is monitored by reference to the aiming point and the power adjusted as required to maintain a steady rate of descent to touch down – power controls the rate of descent. If the aeroplane is correctly trimmed the power adjustments will be very small.

Once established on final, full flap is selected and the airspeed progressively decreased, by adjusting the attitude, to achieve the nominated target threshold speed (V_{TT}) by about 200 feet agl. Power will generally need to be adjusted as speed is decreased.

It is important to carry some power into the flare.

If the aeroplane is not properly configured by 200 feet agl on final approach – that is, on centreline, on correct glideslope, aim point identified, and airspeed correct – go around!

The landing is carried out in one phase. The round-out and the hold-off are combined into the flare (a reduction in rate of descent to zero). The aim is to reduce the rate of sink to zero at the same time as the main wheels touch the ground and the throttle is closed.

The nosewheel is lowered, then brakes immediately applied as required; elevator backpressure is used to keep the weight off the nosewheel. Do not use excessive braking.

Flap is raised on completion of the landing roll.

Airborne Sequence

On the Ground

The distance required for takeoff has been determined as adequate, and flap has been selected in accordance with the Flight Manual.

The Exercise

Before Line-Up

The conditions are assessed and compared with the conditions that were used in calculating the required takeoff distance.

A decision is made on the rotate and takeoff safety speed for the existing conditions.

A safe height, at which to accelerate to best rate or the normal climb speed, is nominated dependent on the height of obstacles in the climb-out path. An obstacle clearance altitude (OCA) is stated, rather than a height above ground, as an altitude is what the student will see on the altimeter.

The OCA should be varied during subsequent exercises to simulate clearing various obstacles in the climb-out path.

The pre-takeoff safety brief is completed, with emphasis on a positive check forward, in the event of an EFATO.

On Line-Up

Full runway length is used, and the high reference point is chosen.

If propeller damage is a possibility because of a loose surface, the aeroplane is not held on the brakes. The minimum static rpm is confirmed as soon as full power is applied. At the point of brakes release, always check that the student drops their heels to the floor.

Landing

Except for extending downwind a little to ensure power is used throughout the entire approach, the turn onto base, base leg and the turn onto final are all normal.

On final (it may look like the profile is too low, due to the downwind extension) full flap is selected.

The airspeed is progressively reduced to the nominated target threshold speed by 200 feet agl.

To reduce the airspeed, the nose attitude will need to be raised, and this usually results in the student assessing the approach as high, with a consequent immediate reduction in power.

During a normal approach the aeroplane is flown down the approach path at 70 knots, whereas during this exercise the aeroplane sinks down the same or steeper approach path at progressively decreasing speeds, only the attitude and airspeed are different. The approach profile should never be flat and low.

The importance of selecting an attitude for the required speed, particularly the V_{TT}, and trimming the aeroplane to maintain that attitude, cannot be over emphasised.

If the aeroplane is not properly configured by 200 feet agl, or the landing is not assured for any reason – the student should be taught to go around.

Do not allow the student to round off the approach or target threshold speeds to the nearest mark on the airspeed indicator.

> A full-stop landing should always be made when flying this exercise.

After Flight

The student will have plenty of time to practise these takeoffs and landings in their circuit flights.

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Te Mana Rererangi Tūmatanui o Aotearoa

Low Flying Introduction

Commonly, low flying refers to any flight at or below 500 feet agl that may be practised only in designated low flying zones.

By maintaining good situational awareness, it should be possible to avoid the unplanned operational need for low flying, for example, as a result of weather, however, pilots need to be familiar with flying low. This exercise allows them to observe the effects of inertia, to experience the visual illusions caused by drift and a false horizon, and to recognise that the stress of low flying is a situation to avoid.

It is important for the student to be exposed to operating close to the ground, not only when forced to fly low, but also when mountain flying. It improves the student's awareness of terrain and the effect of wind. Good aviation practice dictates that a pilot should never fly lower than they must, however, each takeoff and landing involves low flying operations, where the recognition of potential visual illusions is critical.

Whether the designated low flying zone is over water or not, limited value will be found in this lesson if winds are less than 10 knots.

These lessons will not make anyone an expert at low flying. Setting personal limits well above the legal minimum, always leaving a way out, and turning back or landing at the nearest suitable aerodrome long before the situation simulated in this exercise is reached – cannot be stressed enough.

Better to be on the ground wishing you were flying, than airborne wishing you were on the ground!

Objective

To compensate for the effects of visual illusions, inertia, and stress when operating the aeroplane close to the ground.

Considerations

Inertia

The effects of inertia and the sensation of speed become most apparent at low level. At normal cruise speeds the degree of anticipation and the amount of horizontal airspace required to turn the aeroplane is substantial.

Visual Effects

The effect of wind is very apparent at low level and this can lead to quite powerful visual illusions.

When flying into wind at a constant airspeed the groundspeed is low and this can lead the student into either lowering the nose or increasing power.

Downwind the groundspeed is high and this may result in the nose attitude being raised or power reduced.

When flying across the wind the effect of drift is most noticeable. A suitable reference point on track must be chosen. In order to track towards this reference point, the appropriate amount of drift must be offset and balanced flight maintained. Avoid any tendency to fly with crossed controls.

When turning from into-wind to downwind an illusion of slipping into the turn will occur and likewise, when turning from downwind into the wind, an illusion of skidding out of the turn will occur. The strength of this illusion increases in proportion to the wind strength. Never attempt to correct an apparent skid or slip with rudder. Cross-reference to the balance indicator during low-level flight is vital.

Many designated low flying zones are over water, and flight over calm water, with its lack of texture, produces depth perception problems (empty field myopia). For this reason, low-level flight over water in less than 10 knots of wind is not recommended.

The Poor Visibility Configuration

The poor visibility configuration for your aeroplane should be stated and its benefits explained.

In the poor visibility configuration, the airspeed is reduced, flap is extended (generally 15 to 20 degrees depending on aeroplane type (refer CFI)).

The benefits are as follows.

Reduced Airspeed

This means less inertia and a lower groundspeed, allowing more time to think and react to obstacles as well as reducing the radius of turns.

Flap

Flap increases the lift and drag and adversely affects the L/D ratio. The increased lift results in a decreased stall speed, allowing safe flight at the lower airspeed. The adversely affected L/D ratio means a relatively high power setting must be used to maintain straight and level flight.

Power

Maintaining the rpm in the normal range means that the continuous use of carburettor heat is not required, and operating temperatures and pressures should remain within their normal ranges. However, prolonged use of this configuration may lead to increasing oil temperature.

Power also reduces the stall speed and provides slipstream. Slipstream not only provides additional effectiveness to the rudder and elevator (for most aeroplanes) but also helps to clear the windscreen in drizzle.

Remember from the turning lessons, power must always be increased in turns. The level of power required increases as the angle of bank increases.

Low Flying Zone

Management of the exercise requires a careful inspection of the low flying zone and preparation of the aeroplane before entering the area.

Low flying must take place within the boundaries of a designated low flying zone. The boundaries of the area should be described with reference to a map or terminal chart and the minimum descent height stated. Flight below 200 feet agl is not recommended (refer CFI).

If low-level flight is to be conducted over water, lifejackets should be worn, not just carried in the aeroplane.

A broadcast or report, including the estimated elapsed time (EET) to be spent in the zone must be made on entering – and a vacating report when leaving.

Airmanship

When flying close to the ground, if the aeroplane's high speed and inertia are combined with conditions of poor visibility, there is little time to react to obstacles or plan a course of action. Therefore, to better manage the flight, the use of the poor visibility configuration is recommended.

It should be noted that most low flight will be in the normal cruise configuration. The need for training in the operational application of the poor visibility configuration is relevant but raises the questions; "Have I gone too far?" "Should I turn back?" "Should I take an alternative route?" "Should I consider a precautionary landing?"

The use of the term poor visibility rather than bad weather configuration is recommended, because bad weather is not necessarily perceived by the student as poor visibility; for example, turbulence. If the weather is otherwise fine but the aeroplane is experiencing severe turbulence (where the aeroplane's structural load limits may be exceeded), the student may consider this to be bad weather! However, in such situations, if the poor visibility configuration is selected, extending flap usually reduces the aeroplane's maximum structural load limits (refer Flight Manual).

For this purpose, many organisations adapt the **HASELL** checklist, adding an extra L for lights (refer CFI).

H ***Height (not altitude)***
Not below 200 feet above ground level (refer CFI).

A ***Airframe***
State the configuration.

S ***Security***
No loose articles, harnesses secure (life jackets).

E ***Engine***
Fuel on fullest tank, fuel pump ON, mixture RICH and a full SADIE check is completed. Check for carburettor ice.

L ***Location***
The boundaries of the low flying zone are positively identified.

L ***Lookout***
Look into the area for indications of wind direction and strength, possible causes of turbulence (tall trees or cliffs) and downdraughts, other aircraft, birds, obstructions (especially wires) and suitable forced landing sites – as little time for field selection will be available from low level.

L ***Lights***
Turn on all external lights, especially the landing light.

Since ordinarily there would only be one aircraft in the low flying zone at a time, the student may be wondering, why turn on the landing light? The reason is that birds have been shown to be more sensitive to bright lights than moving objects. This is one reason why landing lights are commonly used below 1000 feet during takeoff and approach.

Aeroplane Management

Carburettor heat is cycled more often throughout low flying.

Fuel management needs to be considered if additional power is required to control speed or overcome the drag associated with the use of flap.

Human Factors

Discuss the difficulty of detecting obstructions at low level (wires, birds) against a cluttered background.

Discuss the need to be aware of low flying sensations and potential illusions. Challenge any mindsets to help avoid the need for reactive actions because visual cues have been misleading.

Flying the aeroplane close to the ground in poor visibility can be a very stressful situation. The poor visibility configuration increases the time available for processing. High stress levels result in a decrease in performance and may cause a narrowing of attention by fixating on one instrument or aspect, and/or hyperventilation.

Avoiding bad weather will eliminate one reason for low flying altogether.

Air Exercise

Low Flying Zone Boundaries

Complete the **HASELL** checks and at 1000 feet agl fly around the edge of the LFZ.

Using a powered descent, enter the LFZ at 500 feet agl.

Visual Illusions

At 500 feet agl it can be hard to identify the horizon, unless you are over water, so the horizon will need to be superimposed over the terrain. This will be covered in more detail in the *Mountain Flying* lesson(s).

The most common illusions are those caused by wind. Look specifically at the effect wind has on turning, and how to track over the ground with a crosswind. In addition you should note the effects of flying upwind and downwind on the groundspeed.

The Effects of Inertia

Maintain straight and level at 500 feet agl and note the reaction time needed to initiate a manoeuvre.

Complete medium level turns and note the reaction times required and the radius of turn.

3-D Effect

At lower levels the three-dimensional effect of terrain and obstacles is more apparent. In this light, such things as wires, sun strike, shadows, and mechanical turbulence need to be discussed.

Poor Visibility Configuration

Reduce the power to ________ rpm (refer CFI) while maintaining straight and level flight and when the airspeed has reduced to inside the white arc, lower the flap to ________ degrees (refer CFI). As the airspeed approaches the nominated configuration speed, power is increased, as required, to maintain straight and level flight at the nominated speed. Trim.

The level to which the power will need to be increased varies depending on the aeroplane weight and other factors. At typical training weight and configuration this setting will be about ________ rpm.

Note the reduced speed and how this gives the pilot more reaction time, lessens the effect of wind and inertia, and with a lower nose attitude improves the visibility over the nose.

Airborne Sequence

On the Ground

Make sure there are no loose objects.

The Exercise

The low flying zone should be identified by the student flying around the outside of the boundary, at a minimum of 1000 feet agl, keeping it on the left or student's side so that the student can look into the area.

The student should complete the **HASELL** checks and enter the low flying zone using a powered descent.

The effects of inertia, resulting in a large turning radius and requiring anticipation, are experienced by the student in the normal cruise configuration. This is best achieved by having the student follow a winding road or river. If these features are not available within your low flying zone, flying around the boundaries at 500 feet agl may substitute. Note that the visual impression of greater speed becomes more noticeable as height is reduced.

Level medium turns through 360 degrees may also be practised (refer CFI).

Describe the sensations and potential illusions the student may encounter.

The student should then be taught the poor visibility configuration as discussed in the briefing.

This will usually be the first time the student has ever flown the aeroplane level in this configuration. Therefore, allow adequate time for student practise (refer CFI). Remind the student of the need to use power in the turn, especially with the flap lowered.

In this configuration, the effect of visual illusions created by flying across the wind, downwind and upwind can be experienced by the student and compared with the previous cruise configuration. In addition, the visual effects of slipping into the turn when turning downwind and skidding out of the turn when turning into wind are seen.

The visual illusions caused by drift on the track made good are first demonstrated by flying along a line feature at right angles to the wind. Crossing the aeroplane's controls is avoided by choosing a reference point on which to maintain level balanced flight, and regular cross-reference to instruments – especially balance.

The effects of groundspeed changes and apparent slip or skid are commonly demonstrated by establishing a race track or circuit type pattern at less than 500 feet agl.

Medium level turns are practised in this configuration as part of the race track or circuit pattern. Medium level turns through 360 degrees may also be practised (refer CFI).

On completion of the exercise you may gain some insight into whether or not transfer of learning has occurred by simply asking the student to "take me home."

The student has been previously taught that, before raising flap, there are three criteria that must always be met: safe height, safe airspeed (above a minimum and accelerating) and a positive rate of climb. These will be achieved only by using full power!

Returning the aeroplane to the clean configuration, in anticipation of a climb out of the low flying zone should be treated as a go around.

After Flight

The next lesson will look at some further considerations of low flying and additional types of turns, and why they might be needed.

Low Flying Consolidation

Turning at low level in the poor visibility configuration is slightly different from turning in the cruise at altitude. When turning during the cruise at altitude, a reduction in airspeed or some altitude loss is not necessarily dangerous. However, at low level and low airspeed, in the poor visibility configuration, it is vital to maintain altitude and airspeed.

The reasons for practising turning at low level is to improve confidence and flying accuracy, as well as to prepare against the possible need of operating in deteriorating weather.

Maintaining situational awareness to avoid the need for these techniques cannot be over stressed.

The constant radius turn is a requirement of the CPL syllabus and may be left out or included at CFI discretion.

Objectives

To compensate for the effects of inertia, visual illusions and stress when operating the aeroplane in close proximity to the ground.

To carry out various level turns in the poor visibility configuration in response to deteriorating weather.

Considerations

Perspective

The look of ground features is changed from a plan view to more of a profile view. This can make map reading and navigation more difficult, due to a reduced radius of visible features, and in hilly terrain may obscure the true horizon. In this situation, the horizon will need to be estimated and more frequent cross-reference to instruments made to confirm performance.

Sloping Terrain

During flight at low level, height above ground is estimated visually, and the altimeter is used as a secondary reference.

A dangerous visual illusion may occur when flying over gently rising terrain. As the ground gradually slopes upwards, there is a tendency to align the aeroplane with the slope so that the impression of level flight is maintained. If the airspeed indicator and altimeter are not cross-referenced regularly, the aeroplane may eventually be brought to the stall. This situation can be particularly dangerous if only the reduction in airspeed is observed.
In an attempt to compensate for the decreasing

airspeed, the pilot increases the power, until a turn away from rising terrain is forced on the pilot at low airspeed and full power – usually resulting in a stall in the turn.

Terrain rises steeply in New Zealand, with the gradient of a significant proportion exceeding the climb performance of the average training aeroplane.

Turbulence

Turbulence at low level is generally more pronounced, and the effects of updraughts and downdraughts more significant.

Avoid flying in the lee of hills or the centre of valleys. Turbulence and downdraughts are most pronounced in the lee of hilly terrain. Avoid the centre of a valley because, if a decision to turn back is made, regardless of which way the turn is executed, the maximum turning space will not be available.

Fly on the upwind side of hilly terrain, or updraught side of valleys, where relatively smooth updraughts can be expected. Moreover, if a turn back is required, the full width of the valley is available for turning, and the turn will be into wind, thus minimising the turn radius. Return to the updraught side of the valley after finishing the turn.

Crossing Obstacles

Power lines should always be crossed at the pylons. The pylons are easier to see, and there can be no wires above the pylons or the aeroplane. Many high-tension power lines have a very thin earthing wire stretched between the pylons, well above the main cables. It is very difficult to see.

Ridges should always be crossed at an oblique angle. This method requires less bank angle if a turn away from rapidly rising terrain or downdraughts is required.

Crossing ridges and passes is covered in more depth in the *Terrain and Weather Awareness* lesson, and further in the *Mountain Flying* lesson.

Airmanship

The boundaries of the low flying zone and the minimum permissible height are revised.

Solo flights must be **specifically and individually authorised immediately before** the intended flight.

Some organisations do not permit solo low flying practise at all (refer CFI).

For authorised solo flights in a low flying zone, the Civil Aviation Rules require that the pilot-in-command must be "satisfied that there are no other aircraft in the area."

Revise flight over water if applicable.

Make a careful inspection of the low flying zone, and prepare the aeroplane before entering the area (**HASELLL**).

A broadcast or report, including the estimated elapsed time to be spent in the area, must be made on entering the low flying zone; a vacating report must be made when leaving.

Aeroplane Management

Restate the poor visibility configuration for your aeroplane. Re-emphasise that good management of the whole flight should negate the need for using the poor visibility configuration.

Prolonged use of the poor visibility configuration may affect flight planning (fuel reserves or daylight) and engine operating temperatures. Use **SADIE** more frequently.

Human Factors

Be aware of the visual illusions created by drift, and maintain a regular crosscheck of instruments, especially the balance indicator.

Air Exercise

Medium Turn

When entering a medium turn in normal cruise, the angle of attack is increased by increasing backpressure to maintain height, and the reduction in airspeed is ignored, for example, 90 knots reduces to 87 knots.

When turning, even at medium angles of bank, in the poor visibility configuration, no reduction in airspeed is acceptable. Therefore, in order to maintain the nominated configuration speed, increase the power.

The required power increase for a medium turn is generally quite small.

Steep Turn

Steep turns in the poor visibility configuration are generally restricted to a maximum of 45 degrees angle of bank. There are two reasons for this.

Firstly, as covered in the *Steep Turns* lesson, the increase in drag and the stalling speed are not proportional to angle of bank but are exponential. Therefore, as the angle of bank increases beyond 45 degrees, both the stalling speed and drag rapidly increase.

With the aeroplane already operating at a low airspeed, there is little margin for an increase in the stalling speed. In addition, the amount of power required to maintain altitude at angles of bank greater than 45 degrees may not be available as a result of the rapidly increasing drag.

The second reason involves the aeroplane's structural limits. Most aeroplanes have a reduced maximum G-load limit when flap is extended; for example, the PA38 is limited to +2.0 G when flap is extended, and this G loading is reached at an angle of bank of 60 degrees.

When entering the steep turn from normal cruise, backpressure is increased to maintain altitude and, although the increase in drag is not ignored beyond 30 degrees angle of bank, some decrease in airspeed as a result of the substantially increased drag is expected and acceptable.

When entering the steep turn at low level in the poor visibility configuration, however, absolutely no decrease in airspeed is acceptable, because of the small margin over the stalling speed.

So as to maintain this margin over the stall speed, power is increased on entry; the power increase required may be substantial, although not necessarily full power.

During the turn, attitude, angle of bank, speed, and balance are monitored.

If altitude is being lost, reduce the angle of bank, increase power if necessary. If full power has been applied and altitude is still being lost, there is only one option available – further decrease the angle of bank – quickly!

On exiting the turn, power is reduced in anticipation during the rollout, keeping the airspeed constant.

Obstacle Avoidance or Reversal Turn

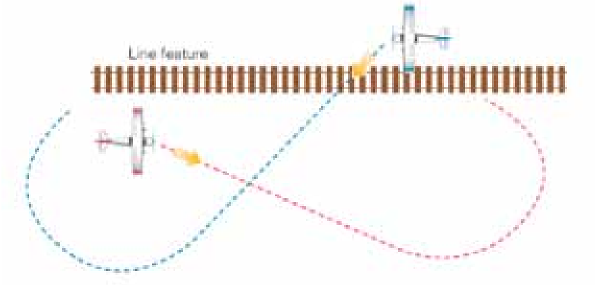
This is a 180-degree turn to avoid an obstacle ahead or poor weather ahead. The direction of the turn is dictated by the wind, but in nil wind conditions turn left or right to maximise visibility.

It is common practice during basic training to simulate the worst case scenario. Therefore, this exercise assumes a line feature is being followed (road, river or railway line) in conditions of poor visibility and an obstacle appears ahead, or a decision to turn back is made. A turn 45 degrees off the line feature downwind is made to allow sufficient space to turn back into wind, to cross the line feature and return with the feature on the left is recommended (an allowance for drift may be required).

It is important to maintain visual contact with the line feature throughout the manoeuvre.

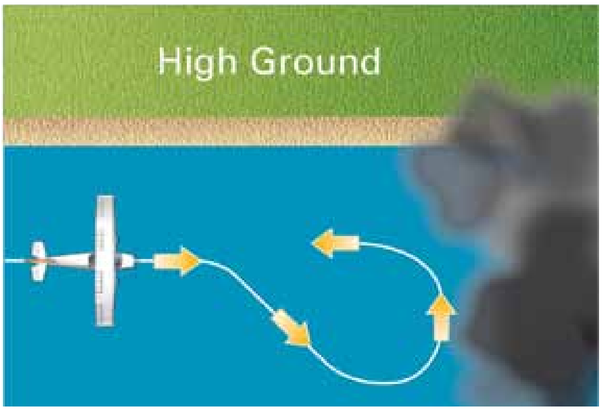
Note, however, that an earlier decision to turn back, probably in conditions of better visibility, may have required only a medium turn.

Figure 1



Coastal Reversal Turn

Figure 2



Once again the worst case scenario is simulated. An obstruction ahead or weather requires a turn back when the feature being followed is the coastline. Simulated poor visibility means no definable horizon is available seaward, and the coastal terrain is simulated as being higher than the aeroplane.

The aim of this manoeuvre is to keep the reference (the coast) in sight throughout the turn to seaward and then track back along the coast in the opposite direction.

This procedure should not be confused with an instrument procedural turn. The coastal reversal turn is a totally visual procedure, with cross-reference to instruments being only for accurate flight. Throughout the procedure, the reference (the coast) must be kept in sight.

The wind direction and strength will determine which heading is chosen to track away from the coast to provide enough space to complete the reversal turn.

With the wind parallel to the coast (head or tailwind), a turn away from the coast of about 45 degrees is recommended. This may be backed up by a DI heading or simply estimated. Keep the coast reference in sight and track out far enough to ensure sufficient space to complete the turn.

If the wind is offshore, and depending on wind strength, tracking out at a lesser angle and/or a shorter time is used to remain closer to the coast while still ensuring sufficient space to complete the turn.

If the wind is onshore, tracking out at a larger angle is not generally recommended because of the difficulty in keeping the reference in sight. However, if the coastal terrain so dictates, there will be no choice. This is a good reason to turn back well before the situation deteriorates to this degree.

The angle of bank used in the initial turn away from the coast will be influenced by the pilot's ability to keep the reference in sight. If the coastline is on the lefthand side, a larger angle of bank can be used than if the coastline is on the righthand side.

When the distance out has been assessed as enough, the turn is reversed, turning toward the reference (coast) to keep it in sight.

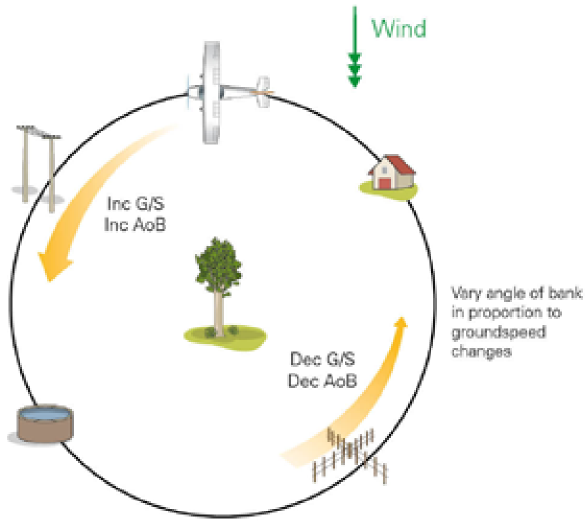
In this reversal, a steep turn should be entered, and as soon as it is obvious that the turn can be completed within the space available, the angle of bank can be reduced.

Starting the reversal with a medium turn is not recommended. If it becomes obvious that a steeper angle of bank will be required, this may not be possible while maintaining altitude.

Constant Radius Turn

The aim of a constant radius turn is to counteract the effects of drift while turning in order to maintain a constant distance from a ground reference.

Figure 3



It is simplest to identify four points equidistant from the feature/reference point to scribe a circle around. Maintain a constant radius by overflying each of the four points on the circle, applying the principle; increasing groundspeed, increase angle of bank, decreasing groundspeed, decrease angle of bank. This will account for the drift.

Airborne Sequence

The Exercise

The medium turns can be practised by the student, and depending on the student, they may be able to practise steep turns without a demonstration from you.

Demonstrate the obstacle avoidance or line feature reversal turn, and then the student should practise.

Taking into account the wind direction and strength, discuss the manoeuvre with the student before you demonstrate the turn in both directions. The student can then practise as you talk them through, followed by their own practise.

Repeat for coastal reversal turn scenario.

Demonstrate the first constant radius turn and from then on the student should be able to practise this with coaching from you.

After Flight

The next lesson will be using the newly acquired low flying skills and should be *Precautionary Landings*.

Precautionary Landing

This exercise primarily discusses the procedure to follow in the event of being forced to land at other than a recognised aerodrome.

It differs from the forced landing because for this landing the aircraft has power and it's possible to choose the best landing site.

If, due to a lack of situational awareness and/or poor flight planning, the pilot becomes hopelessly lost, is running out of fuel or daylight, or is forced to fly in conditions of poor and deteriorating visibility, they may be forced to consider landing anywhere suitable.

If for any reason pilots find themselves in this situation, they should accept the mistake – and not make another one by pushing on.

The decision to make a landing off-aerodrome will create considerable stress. However, the longer the landing is put off, the more limited the options.

Avoid this whole situation by careful pre-flight planning and by choosing to turn back or divert early.

Objective

To learn the procedure to adopt in the event of an off-aerodrome landing.

Considerations

The reasons an off-aerodrome landing may be required are discussed, with particular emphasis on how to avoid these situations.

Weather

Pushing on into deteriorating weather is the most common cause, and is the easiest to avoid.

Avoid this situation by setting personal meteorological minima well above the legal minimum. Have a careful consideration of the weather before any flight and always have an escape plan. See the *VFR Met* Gap booklet for more strategies.

Lost

Becoming hopelessly lost would not necessarily require the implementation of this procedure, but it is considered here in conjunction with one or more of the other reasons.

Becoming lost is avoided by maintaining situational awareness and careful pre-flight planning.

Fuel

Running out of fuel, which may result from becoming lost or trying to get around weather, rather than diverting early, is a situation that will heighten any existing stress levels.

Careful pre-flight planning and in-flight fuel monitoring will help avoid this situation.

Daylight

Most organisations require all aeroplanes to be on the ground, or in the circuit, 30 minutes before Evening Civil Twilight (ECT). This is a sensible precaution – apply the traveller's golden rule: start early, finish early.

If any of the above situations have developed, the recommended procedure is to adopt the poor visibility configuration and carry out an off-aerodrome landing. To execute the recommended procedure may take about 15 to 20 minutes, so a timely decision to avoid additional stress is recommended.

Airmanship

Making an early decision to land gives more time available to make the plan.

Continued wind awareness.

The appropriate passenger briefing and security checks are carried out.

In the real situation make a PAN call and squawk 7700. If the outcome doesn't look favourable you may wish to make a MAYAY call (refer CFI). Consider activating the ELT.

As with all low flying, more frequent use of **SADIE** checks is advised.

The minimum descent altitude for this exercise is restated (refer CFI).

Aeroplane Management

Consider the poor visibility configuration to slow things down and allow for the increased stress. If the landing is because of bad weather, carburettor heat needs to be considered. If it is due to a low fuel state, manage the landing within the available fuel.

Human Factors

When flying at low level or in reduced visibility, disorientation can quickly occur. The student will need to make an enhanced effort to remain orientated.

Stress has a significant effect on decision making, situational awareness, mental workload, problem solving, and performance. Minimising stress involves good aviation practice to avoid the situations that call for this procedure, overlearning the procedure to deal with it, and applying effective stress management techniques.

Air Exercise

This exercise is carried out in the low flying area, unless this is over water. The low flying area pre-entry checks and radio calls are made. If the exercise is to be simulated by maintaining 500 feet agl outside the low flying area, amend the briefing as required.

Simulating the Conditions

Descending to 500 feet agl simulates a lowering cloud base and reduced visibility. The poor visibility configuration is adopted, and the decision to land off-aerodrome is simulated.

With the decision made to discontinue the flight, a search for a suitable landing site is initiated, the emergency is declared, and the passengers and cabin secured.

Assessment of the wind is based on the same indicators as the forced landing, with the importance of drift increased.

Landing Site Selection

Revise the S's, C and E – Size, Shape, Slope, Surface, Surrounds, Stock, Sun, Communication and Elevation. Power will be used to maintain an estimated height above ground level, but avoid operating unnecessarily low, as this will only increase any stress levels.

If time permits, a suitable landing site with ground assistance nearby can be chosen.

The position of the sun may be a major factor in the choice of a suitable landing site, especially if the onset of ECT is the reason for landing.

The length of the landing site can be assessed by flying into wind, from fence to fence in the direction of landing and timing how long it takes. Two knots is equal to approximately 1 metre/second. Assuming the airspeed is 70 knots, then groundspeed is about 70 knots. If the time it takes to fly the length of the landing site is 10 seconds at 70 knots, then that is equal to approximately 350 metres. If the basic landing distance is known the landing site can be assessed as suitable or not.

Alternatively superimposing a known and acceptable image over the selected site such as "looks about the distance between the threshold markers and the 500-foot markers of the home aerodrome", ie, 150 metres.

If no obvious landing areas are visible, a turn downwind will give a larger choice of landing sites in the same time.

The Pattern

Once a landing site into wind has been selected for closer inspection, flight overhead at right angles to the landing option/vector can help determine if a left or right hand circuit is the best option. It will also confirm the wind assessment through drift, and provide an opportunity to look at the approach and overshoot paths before any descent. It may also provide cues to help identify any gradient.

In low cloudbase situations, it is recommended that the circuit altitude be established at about 100 feet below the cloud base. This provides both maximum visibility and ground clearance.

Ideally the aeroplane is positioned into wind at 500 feet agl with the chosen landing site on the lefthand side, far enough out so the pilot can look across at the landing site and assess it in relation to the S's.

On this and subsequent legs, the chosen landing site is assessed in relation to the S's, with particular emphasis on surrounds in the approach and climb-out areas.

Landmarks are chosen (if available) at the beginning and end of each circuit leg to help remain orientated in case the pilot loses sight of the landing site.

In addition, on the first upwind leg the heading of the landing direction is generally noted. To reduce mental workload, however, another method is to align the DI to north while on this leg, regardless of actual heading. Each leg of the required circuit will now have a cardinal heading in nil wind and the landing will always be carried out on a heading of north.

On the downwind leg, spacing is assessed using the same airframe reference as a normal circuit. Since the short field landing technique will be used, the downwind leg is extended – visibility permitting.

At the end of the downwind leg, a ground feature (if available) is selected as a turning point reference.

Assuming the chosen landing site appears suitable up to this point, a second inspection is carried out at a minimum of 200 feet agl.

The base leg is extended through the centreline and the aeroplane turned into wind, with the landing site on the lefthand side, but closer than during the first inspection. This inspection is to decide exactly which side or part of the landing site will be used for the landing roll. Are there any tree stumps in the long grass?

Established on and parallel to final, a gradual descent to a minimum of 200 feet agl is carried out.

Descent below 200 feet agl is not recommended, because it takes considerable concentration to fly the aeroplane level and look at the landing site surface. Also, there is a possibility of unseen obstructions, and since a climb to 500 feet agl will be initiated on completion of this inspection, the climb is minimised.

The major portion of the aeroplane's inertia will be spent in the first two thirds of the landing roll. Therefore, it is generally recommended that the low-level inspection is not prolonged, but a climb to 500 feet agl initiated about two thirds of the way along the landing site (refer CFI).

Ensure the decision points for the approach and aim point are easily identifiable because unlike a forced landing, time to go around in the event of a poorly executed approach should be available.

Climb out in the poor visibility configuration to 500 feet agl. Generally, this climb-out is not treated as a go around with appropriate configuration changes, because re-establishing the poor visibility configuration on reaching 500 feet agl increases the workload.

The aeroplane is re-established on the downwind leg, the passenger briefing is completed, and a short field approach and landing is carried out.

The Landing

During the landing roll, use maximum braking, avoid major obstacles and above all else, keep the cabin intact.

After landing, the shutdown checklist is completed.

Airborne Sequence

The Exercise

The student should be capable of positioning the aeroplane within the low flying area, checks complete at 500 feet agl, and established in the poor visibility configuration.

To inject some realism to this exercise talk the student through the scenario. The weather has deteriorated, they are not entirely sure of their position, and it is starting to get dark – they need to carry out a precautionary landing.

First they must find a suitable landing site. Have the student talk you through what they are looking for, while you fly the aeroplane. They should remember the S's from previous lessons and the briefing.

Take some time to discuss all of the elements. Although a time constraint may be introduced in later flights, allow the student enough time to complete the recommended inspections.

Now set the aeroplane up in the pattern. Choose the landmarks, note the heading of the landing direction, descend to 200 feet for the closer inspection, and time the downwind leg to calculate landing distance available.

Consider the decision making points for the approach and aim point, if they are not achieved a go around will need to be executed to reposition for another approach.

Continue the circuit and set it up to land. The height at which you execute a go around will be determined by your CFI.

Now let the student practise, while you monitor their progress.

After Flight

Re-emphasise to the student that this is a last resort procedure, and the best course of action is not to get themselves in this position in the first place.

CIVIL AVIATION AUTHORITY OF NEW ZEALAND
Te Mana Rererangi Tūmatanui o Aotearoa

Terrain & Weather Awareness

This training should expand on the syllabus requirements of low flying, to incorporate an increased level of experience and understanding of flying near terrain and its associated weather, especially wind.

Fundamental to safe flight near terrain is the ability to establish an appropriate horizon reference when the visual horizon is not available, because of terrain or weather.

It is important to develop the student's awareness of space and inertia while they are operating in a confined space using an imaginary horizon.

These exercises do not require high mountains to establish the basic principles.

The introduction exercise could be completed in most low flying areas. Where this is not possible flying at 500 feet agl above an open area with a definable 'confined area' of approximately 500 metres x 500 metres will meet the requirements. This is followed by replicating the exercise within a valley, where a real horizon is not available.

Opportunities for scenario based decision-making should be maximised.

Terrain awareness training should focus on recognising the significance of weather, especially wind, relative to the terrain and its impact on flight conditions and flight path.

Objectives

To establish a useable horizon reference when the actual horizon is not available.

To operate in a confined area.

To develop further awareness of space and inertia when confined by terrain.

To safely cross ridges, saddles, passes or spurs.

Considerations

The student should experience the exercises in a variety of configurations and conditions;

1. In both the clean configuration and poor visibility configuration.
2. In both calm and light wind conditions (less than 15 knots).
3. In clear conditions and with some precipitation.
4. They should complete turns through 180 degrees and 360 degrees both clockwise and anticlockwise.

Superimposed Horizon

Define the horizon as where the sea meets the sky.

Identify the real horizon.

An imaginary horizon can be used when the real horizon is obscured by terrain or weather. The horizon can be imagined by visualising the obstruction (terrain or weather) as transparent, and visualising where the sea would meet the sky.

Operating in a Confined Space

Define a simulated confined area, free of obstacles and with clearly defined boundaries. A flat paddock of approximately 500 metres x 500 metres would suit most light training aircraft.

Define a similar area in a location where a clear horizon is not available.

Discuss how to superimpose the horizon when the real one can't be seen.

Identify a useable imaginary (or real) horizon by visualizing where the sky meets the sea, as if the terrain or obstacle to the visual horizon were transparent.

Use this horizon line to reference the nose attitude, whether in straight and level flight or level turning flight.

Review wind cues and how to estimate drift, as covered in the low flying lessons.

Discuss varying the angle of bank in order to use all available space, and the use of power to maintain a safe speed during all manoeuvres.

Discuss the importance of being aware of the wind direction and speed relative to the terrain. Demonstrate how the wind will behave in varying strengths, and how it will flow around and/or over terrain depending on its strength.

Operating in a Valley

Discuss where to position the aeroplane in a valley, considering;

- right of way rules,
- lift and sink conditions,
- use of space – depending upon weather and airspace conditions,
- positioning right of centre in a large valley,
- positioning on the right side in a narrow valley – so that you can immediately escape by turning 180 degrees, should it be necessary because of weather, sink, turbulence, traffic, or running out of space.

Discuss the need to use the minimum angle of bank necessary to use all the space, this will also minimise the stall speed and improve the potential for anticipation by allowing more time to assess factors such as, space, inertia, rate of closure, radius required, turbulence, etc.

The poor visibility configuration will slow the aeroplane down and reduce turn radius, in addition a reduced flap selection may be required to maintain aeroplane performance.

It is important to remember that this exercise is not a minimum radius turn. If a minimum radius turn is required, a good decision is long overdue.

Discuss the use of check turns to assess the available space well before committing to any area the pilot is unsure of.

Crossing Ridges, Saddles, Passes or Spurs

Students will need to take into account all aspects of the crossing including; the approach to the crossing, the actual crossing, and the flight path after the crossing.

When planning a crossing, the approach angles must take into account the effects of wind and terrain, and allow escape options throughout the crossing, that minimise the period of commitment – a 45-degree angle, or less, is ideal.

The aeroplane must be in level flight, speed under control; not in a climb where visibility and airspeed are compromised; not in a descent where V_A may be compromised in turbulence at the saddle and loss of altitude may compromise return options back over the saddle.

The student should be able to use parallax to help recognise the aeroplane's height in relation to the saddle. If the terrain beyond the saddle is disappearing, the aeroplane is not high enough. If there is increasing terrain beyond the saddle then the aeroplane is higher than the saddle. Discuss how much terrain clearance is needed for a safe crossing.

Discuss the types of saddles, and their relative merits. A knife-edge saddle is the most preferable because of the shorter time it takes to cross; it allows for a shallow angle of approach (45 degrees or less) and allows a shallow angle of escape.

It is critical that escape options are always available. The effects of weather, terrain, traffic, turbulence, sink, and confined turning radius can require the use of an escape option at a moment's notice. These escape options should be downstream, downhill and through the minimum possible angle of bank, in order to maintain a margin over the stall in anticipation of potential sink or turbulence.

Airmanship

Thinking ahead of the aeroplane is an important part of this exercise. In the real situation it will ensure that the student does not find themselves forced into reacting to an 'unforeseen' situation.

Good decision making is critical, especially crossing ridges and passes, to maintain escape options and to minimise any commitment period.

The student must remain aware of their situation at all times, in particular remaining aware of the changing weather, nearby terrain, other traffic in the area, and the student's own performance.

It is helpful to make position reports both before and after crossing a saddle or pass to assist with traffic awareness.

As with all low flying, more frequent use of **SADIE** checks is advised.

The minimum descent altitude for this exercise is restated (refer CFI).

Aeroplane Management

Revise the poor visibility configuration – considering when it is necessary to adopt and the effect it has on performance.

Review V_A, V_S, and operating speed range considerations. Review the use of power as necessary to remain safely above stall speed, but in anticipation of potential turbulence, below the maximum manoeuvring speed.

Carburettor heat as required.

Fuel management.

Review leaning the mixture for engine considerations, performance and economy.

Revise control coordination to ensure smooth, balanced handling to reduce unnecessary stress on the aeroplane, passengers and pilot.

Consider the positioning of the aeroplane in relation to the terrain while taking into account wind direction and speed, so as to mitigate the effects of turbulence.

Human Factors

Good planning and situational awareness will reduce disorientation.

Discuss the illusions associated with inaccurate horizon definition, most commonly an insidiously climbing terrain gradient which tricks the pilot into raising the nose.

Potential hazards associated with illusions and poor horizon definition include inadvertently reaching the stall speed with high power and no room, or performance, available to escape.

Motion sickness can be a problem, use the **I'MSAFE** checklist, good planning and training to reduce anxiety levels. Use smooth coordinated control inputs, and provide sick bags as a backup.

Direct the student towards more reading on this subject, there are a number of GAP booklets that deal with flying in mountains, *Mountain Flying*, *Survival*, the *In, Out and Around* series, as well as the *Mountain Flying* DVD.

Air Exercise

In the 'confined area' within a low flying area, fly the boundaries using a minimum angle of bank using all the available space. Control the speed with power.

Use the clean configuration and the poor visibility configuration, calm and light wind conditions, as well as no precipitation and some precipitation. Make turns left and right through 180 degrees and 360 degrees.

Repeat the exercise in an area confined by terrain without a real horizon available.

Use saddle crossing techniques to enter or exit this 'confined by terrain' area.

Refer to the *Mountain Flying Training Standards Guide*.

Airborne Sequence

Operating in a Confined Area

Starting with a larger area, and gradually reducing to the smaller 'confined area' will help students to manage this exercise.

In the clean configuration fly the boundaries using minimum angle of bank, using all available space. Repeat in the poor visibility configuration, noting the differences.

Ensure every opportunity is taken to enhance wind awareness, especially noting wind strength and direction.

Relocate from the obstacle free simulated confined area to a suitable valley or gully to carry out the same exercise but near terrain, and consequently a less defined horizon.
Carry out check turns before entering and during early positioning in the valley to make sure the operation is not beyond personal limitations.

Appropriately position the aircraft to execute level 180 degree and 360 degree turns using all the available space, minimising the bank angle and using only sufficient power to maintain a safe speed between V_A and V_S – appropriate to conditions and aeroplane loading.

Crossing Ridges, Saddles or Passes

Determine the lift or sink sides of the saddle. Assess the approach, crossing and after crossing options.

Approach at 45 degrees to provide the best escape downhill, downstream, and with the minimum angle of bank required.

Fly left to right to allow for the best visibility. However, if the saddle is obstructed or the sink is significant, fly right to left.

Show the student the difference between the 'knife-edge' saddle and the flat saddle, choosing the 'knife-edge' to cross at.

Approach level and below V_A, as discussed.

Show the student how to use parallax to assess sink and their height in relation to the saddle.

Have the student gain experience in making decisions using a variety of approach options.

CIVIL AVIATION AUTHORITY OF NEW ZEALAND
Te Mana Rererangi Tūmatanui o Aotearoa

ADVANCED MANOEUVRES

Basic Mountain Flying

This training introduces students to the principles of basic mountain flying and further develops their experience and understanding of operating near terrain with its associated weather. This is a CPL level exercise.

The exercises do not require high mountains to establish the basic principles.

Opportunities for scenario based decision making should be maximised.

As with the previous lesson *Terrain and Weather Awareness* the training should focus, whenever the opportunity presents itself, on recognising the significance of weather, especially wind relative to the terrain and its impact on flight conditions and flight path.

Objectives

To consistently identify a useable horizon and to superimpose it on to a variable background.

To appropriately position an aircraft in a valley and to conduct level, climbing and descending turns.

To safely approach, cross, and position after crossing ridges, saddles, passes or spurs.

Experience real or simulated circumstances of disorientation and the strategies for reorienting in place and time.

To practise emergencies where options may be limited.

Considerations

The student should experience these exercises to increase their awareness of mountain flying and their associated weather;

1. In clean configuration and poor visibility configuration
2. In both calm and windy conditions (greater than 15 knots, at instructor discretion)
3. In clear conditions and in conditions of some precipitation
4. Completing turns through 180 degrees and 360 degrees both clockwise and anticlockwise.

Wind below 15 knots is generally predictable. It is important that instructor discretion is applied in wind conditions above 15 knots, when ability to accurately predict conditions is more challenging and affected by the terrain shape, size and presentation of airflow.

Importantly, basic mountain flying requires completion of a ground course, please refer to the Mountain Flying Training Standards Guide for the content of this course.

Superimposed Horizon

Revise the definition of the horizon.

Identify the real and imaginary horizon.

Review the illusions associated with inaccurate horizon definition, most commonly an insidiously climbing terrain gradient which tricks the pilot into raising the nose. Potential hazards associated with illusions and poor horizon definition include inadvertently reaching the stall speed with high power and no room, or performance, available to escape.

Operating in a Valley

Review and expand on;

- use of check turns,
- positioning in a valley,
- turning using minimum angle of bank to use all available space,
- poor visibility configuration use and considerations, and

Discuss the considerations of climbing and descending turns when entering and vacating a valley. This will help the student to experience the changing horizon perspective and consequent importance of attitude/speed control.

Discuss valley gradients – the student should experience flying at a constant height above the valley floor while descending down a valley to observe the VSI indications and predict the climb performance necessary for flight in the opposite direction. The gradient in most valleys far exceeds the climb performance of the average light training aeroplane.

Discuss the effects of sun and shade – if possible, in a controlled dual environment, expose the student to the sun suddenly appearing/disappearing behind a ridge.

Crossing Ridges, Saddles, Passes or Spurs

Review and expand on the considerations from the *Terrain and Weather Awareness* lesson;

- consider all aspects of crossing,
- configuration and attitude of aeroplane,
- effect of wind and terrain,
- escape options,
- use of parallax, and
- types of saddles.

In increased wind conditions the student will need to assess the areas of lift and sink, and areas of potential turbulence for all phases of a crossing.

The student must consider the approach path/angle from well before the crossing. They must assess the approach angle (left to right or right to left) for wind, cloud and turbulence conditions and provide for the best escape option at all times.

Escape options should be available through a shallow angle (45 degrees or less) to minimise the angle of bank and consequent V_S. The best escape option should provide for a downstream, downhill escape on both sides of the crossing to anticipate the effects of potential turbulence or sink.

The student should experience as many options as possible, including those that may not be the best, provided that the experience stays within the instructor's limitations.

Route Finding

Discuss the importance of good planning and map preparation. The time spent on the ground significantly reduces workload in the air, especially in the mountains where a good lookout is more critical because of the proximity to terrain.

Being able to identify the direction of water flow/gradient will help greatly when it is critical to be assured of the aeroplane's position. The student should develop the skill of recognising flow direction and by assessing the amount of white water present, gain a clear indication of valley gradient.

Being aware of the alignment of the valley being flown in, and of those nearby, will help maintain situational awareness.

Discuss using the position of the sun to improve situational awareness and knowledge of orientation. For example if the sun was in front of the right shoulder entering the valley, and if insignificant time elapses, it should be behind the left shoulder exiting the valley.

Emergencies

Emergency landings, whether forced or precautionary, are more of a challenge when flying below the ridgeline.

The lack of a real horizon is the primary problem.

There are many variables to consider; height available, distance to viable landing sites, existence of viable sites within reach, wind/turbulence/precipitation conditions, and light conditions, to name just a few.

Confined spaces will affect the plan.

The wind will also affect the glide range – avoid the sink and use the lift if possible. It may be possible to take a calculated gamble on the presence of an anabatic or katabatic wind.

The valley being flown over will probably have a gradient – how steep it is? What will be the elevation of the landing site? Are there any wires?

Be aware of the illusions and mindsets that can be experienced.

Make an early MAYDAY call, possibly on 121.5, set 7700 and activate the ELT.

Look for habitation and head for it.

Before takeoff, there should be an appropriate survival kit on board and the pilot should have knowledge of its contents and use. See the *Survival* Gap for more information.

Airmanship

In this lesson the student must be doing more than just thinking ahead, they must anticipate the environment they cannot yet see, in order to ensure they are not left in a situation where reacting quickly is the only option left open to them.

It is important that they learn to recognise threats and develop appropriate strategies to mitigate those threats.

It is much better to have sound decision making than rely on inadequate aeroplane performance to provide escape options.

The student must remain aware of their situation at all times, in particular remaining aware of the changing weather, nearby terrain, other traffic in the area, and the student's own performance.

It is helpful to make position reports both before and after crossing to assist with traffic awareness.

As with all low flying, more frequent use of **SADIE** checks is advised.

The minimum descent altitude for this exercise is restated (refer CFI).

Aeroplane Management

Revise the poor visibility configuration – considering when it is necessary to adopt and the effect it has on performance.

Review V_A, V_S, and operating speed range considerations. Review the use of power as necessary to remain safely above stall speed, but in anticipation of potential turbulence, below the maximum manoeuvring speed.

Carburettor heat as required.

Review leaning the mixture for engine considerations, performance and economy.

Revise control coordination to ensure smooth, balanced handling to reduce unnecessary stress on the aeroplane, passengers and pilot.

Consider the positioning of the aeroplane in relation to the terrain while taking into account wind direction and speed, so as to mitigate the effects of turbulence.

Human Factors

The illusions experienced when flying without a horizon have been discussed earlier, but expand on the other illusions the student may experience, for example, whiteout and disappearing ridgelines.

Workload, stress, fatigue and effect on performance – employ sound planning techniques, good training and currency to reduce any degrading effect on performance

Hypoxia and dehydration factors – be knowledgeable and aware of effects on performance

Direct the student towards more reading on this subject, there are a number of GAP booklets that deal with flying in mountains, *Mountain Flying*, *Survival*, the *In, Out and Around* series, as well as the *Mountain Flying* DVD.

Air Exercise

Review the previous lesson and the skills developed there.

This lesson should start approaching any terrain. Discuss horizon, wind, gradient and potential lift/sink well in advance of the arrival in any valley.

Superimposed Horizon

Fly a constant altitude while maintaining a constant wingtip distance from terrain.

By using outside reference as the primary source, and only confirming performance with instruments, this exercise will help to develop the skill of accurately superimposing the horizon onto varied backgrounds.

This exercise should be flown smoothly and with coordinated control movements. While flying smoothly and maintaining a constant altitude and distance from terrain, encourage the student to develop an awareness of the area around them and their position in it. They should also be gaining an appreciation of inertia when they make turns, be consistently aware of their escape options, be applying the right of way rules, and using an appropriate lookout technique.

Next, fly a constant height above a descending valley floor to give the student an appreciation of gradient and shifting horizon perspective.

Turn around and fly a constant height above a rising valley floor to appreciate the same things.

Operating in a Valley

This is ideally carried out in a valley that provides a variety of slopes, valley sides, background terrain, and weather conditions. This may not be practical so a variety of valleys and conditions should be used.

Turns should be made while level, climbing, and descending.

When either unsure of the radius required, approaching the entrance to a valley, in a narrowing valley, or part of the valley, make check turns to evaluate the turn radius of the aeroplane, exit options and the space available for an escape.

Start with complete 360 degree level turns both left and right, in the cruise configuration, using the full width of the valley. Then the same level turns in the poor visibility configuration.

Note the difference in appropriate aeroplane position when in a narrow valley compared to a large one.

Make steep descending turns into a valley, the student should correctly anticipate the location the aeroplane should roll out, and notice the changing horizon perspective and reduced space available.

The student should be able to make efficient climbing turns, to enable the aeroplane to either climb out of a valley or to position for a saddle crossing using the available lift to assist, and avoiding sudden sun strikes.

If the valley has a vertical face, experience the turning radius through 180 degrees in both the cruise and poor visibility configurations to appreciate the effects of illusions.

Crossing Ridges, Saddles, Passes or Spurs

Apply a CPL standard to the previously established principles of assessing the appropriate flight path for approach, crossing and after crossing, that applies the safest compromise of the options and principles involved.

This exercise will be carried out in wind conditions that may exceed 15 knots.

The student should be able to demonstrate a saddle crossing, while taking into account, the approach, the effect of wind, the turbulence, their height, their speed, an efficient crossing, and be able to show you where they would escape to at any point. A safe airspeed must be maintained at all times and the aeroplane flown smoothly. Where compromise may be required, assessment of the best option should be made.

The student should apply sound decision making to all of their decision-making processes, and be able to discuss these. Their consideration of suitable escape options in conditions of unexpected sink or turbulence should be of primary concern.

Route Finding

While conducting mountain flying training, or during dual cross country training and operating below the ridge line, allow the student to experience their own real disorientation and guide them through strategies for reorientation. If this is not possible you may need to simulate the exercise.

Emergencies

Take opportunities to simulate forced or precautionary landings whenever the aeroplane is below a ridge line. Emphasise the need to recognise and mitigate any threats.

The student may have difficulty adjusting to a situation where the standard pattern cannot be flown, including a forced landing without power where the only option is straight ahead.

Airborne Sequence

Develop local simulated scenarios so you can assess a student's entry into and exit from a valley system, climb into and out of a valley system or crossing from one valley system into another.

When conducting cross country training consider routes and altitudes that facilitate practical application of principles learned.

CIVIL AVIATION AUTHORITY
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