P - BASIC AEROBATICS

SPL Syllabus: Basic aerobatic exercises			
(1) Confidence manoeuvres and recoveries			
(i)	**Slow flights and stalls**	**(v)**	**Spins and recovery;**
(ii)	**Steep Turns**	**(vi)**	**Recovery from spiral dives**
(iii)	**Sideslips**	**(vi)**	**Recovery from unusual attitudes**
(iv)	**Engine restart in-flight (if applicable)**		
(2) Aerobatic manoeuvres as per point SFCL.200(b)(1).			
(i)	**45-degree climbing and diving lines performed as aerobatic manoeuvres**	**(iv)**	**Lazy eight**
(ii)	**Inside loops**	**(v)**	**Spins, with an exit onto a heading**
(iii)	**Wingover**		

INTRODUCTION

Many trainees are excited by the prospect of experiencing some aerobatics in the early stages of their training. Those that wish to go on to learn aerobatic more formally will benefit in terms of:

- improved handling and coordination skills.
- improved confidence, especially in their ability to recovery from unusual attitudes.
- being able to safely undertake and enjoy simple aerobatics.

Hopefully, by ensuring these benefits are maximised by thoughtful and structured training, some trainees will go on to more advanced aerobatics and competitions or become the advanced aerobatic instructors of the future.

These notes are intended to form a basic teaching framework for aerobatics. The emphasis is on making sure that the manoeuvres listed below can be undertaken and enjoyed safely. The relevant parts of theory such as the flight envelope should be taught in more detail in a classroom theory session.

The basic aerobatic manoeuvres in this chapter can be done in any airworthy glider approved for aerobatics. All aerobatics, including the most basic, should be planned and well executed, and within the glider's particular limitations.

It is important that the trainee aerobatic pilot is under no illusions as to exactly which aerobatic manoeuvres they are cleared to fly solo and unsupervised, and those they are not. The logbook and training syllabus progress cards provide an excellent means for conveying this in an unambiguous manner. Logbook entries should aim to provide the next instructor with a clear indication of any problem areas, and things to watch for.

Standard of competence for aerobatic training

There is no reason why some aerobatic training should not be given to ‘appropriate’ pre-solo trainee pilots, to help them build confidence and get accustomed to flight at higher speed regimes. More formal training should only start when a pilot has an SPL.

Instructors should also recognise that aerobatic training provides solo pilots with an excellent, face-saving excuse to fly with an instructor to help sort out flying problems. Such cries for help do occur from time to time and it is important that instructors recognise and respond to them.

Before teaching any aerobatic manoeuvres, a full revision should be done of all the confidence flying manoeuvres including slow flight, spinning and spiral dives (as covered in Chapters 9 and 10).

This revision should not be treated as a box-ticking exercise, but as a progressive refresher to ensure that the pilot is fully comfortable with operating the aircraft at all ranges of the normal envelope. Exercises should be flown with increasing precision and with discussion of what the pilot is experiencing, so that confidence is built step by step. Emphasis should be placed on recognising and recovering from unusual attitudes, handling the aircraft accurately at low and high speeds, and demonstrating positive control in dynamic situations.

The aim is to ensure that both instructor and trainee are satisfied that basic handling skills are secure and that the trainee is mentally prepared for the demands of full aerobatic manoeuvres.

A training syllabus and record card are essential. Ideally training should involve a mixture of dual flying and observed solo flights, with suitable feedback from each.

BASIC AEROBATICS THEORY

(1) <u>Human Factors and Body Limitations</u>

Spatial disorientation

The brain usually has input from the vestibular system in the inner ears as well as visual cues which help orientate us in the environment. Whilst flying aerobatics manoeuvres pilots are subject to motion, speed, forces, and variations in gravity (both positive and negative) which they are unfamiliar with, which can lead to a false perception of orientation and relative movement.

There three specific consequences of this:

- The leans – a false perception of the horizontal
- An illusion of turning in the opposite direction
- The Coriolis – a sensation of tumbling or turning on a different axis.

These illusions can be unsettling if not understood. The leans occur when the body's balance organs adapt to a prolonged gentle roll, so when the aircraft is levelled the pilot falsely feels tilted. The illusion of turning the opposite way can arise after a prolonged or rapid turn, when stopping the turn makes the pilot feel as though they are now rotating in the other direction. The Coriolis illusion happens if the pilot moves their head during a sustained turn, creating a powerful and disorienting sensation of tumbling or turning on a completely different axis. Recognising these sensations as normal illusions and relying on visual and instrument references rather than bodily feel, is key to avoiding disorientation.

The instructor should make the trainee aware of these issues and appropriate methods of avoiding spatial disorientation such as maintaining a disciplined instrument scan, keeping external visual references wherever possible, cross-checking seat-of-the-pants (proprioceptive) sensations against visual and instrument cues, and most importantly, pausing between manoeuvres to re-orient if doubt arises.

If disorientation does occur despite these precautions, the trainee should be taught to adopt a simple recovery strategy: stop any further manoeuvring, level the wings, establish a safe pitch attitude using reference to the horizon, and regain full situational awareness. The emphasis should be on positive, deliberate control inputs and not rushing to continue the manoeuvre until fully re-oriented

Airsickness

It is common for motion sickness to be triggered by the movements of aerial manoeuvres, creating conflicting signals between the eyes, inner ear, and brain. As well as nausea it can cause sweating and dizziness. It may be exacerbated by anxiety, fatigue, and dehydration. To mitigate it, pilots can focus on visual cues like the horizon, maintain hydration, get sufficient air from vents, and avoid stimulants. Some pilots report that anti-nausea medicine helps to alleviate these symptoms, but it is entirely a personal decision for the trainee whether taking such medication is appropriate for them.

It is helpful to gradually increase exposure to more extreme manoeuvres and time spent in manoeuvres to increase tolerance to airsickness. Most individuals gain some resilience over time, but this may vary considerably.

Body stress and G-forces, and effects of grey- and blackouts

Whilst pilots should be aware of the potential effects of G-forces both positive and negative, the most serious consequences such as blackout only occur at sustained levels of G at +8 or -4. These levels of G force are highly unlikely except in specialist gliders doing very high g-manoeuvres. Nonetheless there may symptoms such as dizziness or brief greying out of visions at levels as low as 3.5g particularly with abrupt changes from positive to negative, that the pilot should be aware of. Older pilots may be more susceptible.

<u>(2) Legislation affecting aerobatic flying</u>

Under SFCL legislation SPL holders shall only undertake aerobatic flights in sailplanes if they hold the appropriate aerobatic privileges in accordance with SFCL.200. This section specifies the theoretical knowledge requirements and flight training required. The attainment of the privilege must be documented in the pilot's logbook by documenting completion of the training by the Head of Training – normally the CFI of the responsible training organisation.

Always comply with the Rules of the Air, as set out in the UK Standardised Rules of the Air (UK SERA) and the Rules of the Air Regulations 2015. For more details, read the Skyway Code. Note that Rule 4 of the Rules of the Air Regulations 2015 prohibits aerobatic flight over the congested area such as town or cities. Aerobatic flight in controlled airspace must always be approved by the relevant air traffic control unit.

<u>(3) principles of aerodynamics</u> to include slow flight, stalls, and spins, flat and inverted.

The trainees require an understanding of the basic aerodynamics for the flight manoeuvres they will be performing. Slow flight and spinning are covered in the relevant chapters of the Instructor Flight Manual Chapter 9.

The flight envelope should be covered in greater depth, so it is included as an appendix to this chapter.

Specific reference needs to be made to:

- the graphical pitch plane representation of glider strength (manoeuvring envelope)
- maximum manoeuvring speeds (Va)
- velocity never exceed limits (VNE)
- effect on the manoeuvring envelope of using the airbrakes the ailerons, multiple axis control inputs (e.g. up elevator and right aileron together)
- load factor limits at different speeds
- the specific manoeuvring envelope of the glider to be used for training
- an appreciation of the relative strengths of different glider types.

(4) general airframe and if applicable, engine limitations

It is important that the Flight Manual should be read thoroughly before performing any aerobatic manoeuvre including spins and stalls. Any limitation on manoeuvres must be adhered to and any deviations such as atypical spin recovery must be carefully noted and understood. The placarded limits in terms of weight and balance as well, as limiting speeds in particular Va, and VNE must be carefully noted.

Safety considerations

Aerobatics should only be flown in appropriate weather conditions – e.g. a visible horizon is essential for training flights with a suitable cloud base.

The permission of the appropriate authorities such as the CFI/duty instructor should be obtained before take-off. Let other pilots know that it is an aerobatic flight - start height, approximate area, and position of box etc.

Carefully prepare the glider before flight. A good DI, vacuuming the cockpit and cleaning the canopy - loose items can jam the controls and/or injure the pilot(s)

Other considerations:

- Always maintain an excellent lookout, particularly during between aerobatic manoeuvres.
- Avoiding conflict with local airfield traffic requirements.
- Adhering to pre-agreed altitude limits for aerobatic sorties e.g. from 4,000' to 1,500.'
- Particular attention should be paid to ensuring straps are correctly and tightly fitted during the flight.

Setting and sticking to these altitude limits provides a clear 'hard deck' below which no manoeuvre should be continued. This ensures a safe margin above the ground, helps both instructor and trainee manage workload, and builds the discipline of planning sequences to fit safely within the available height. The instructor should emphasise constant height awareness, the importance of recovering with adequate margin, and terminating a figure early if it risks infringing the agreed lower limit.

(5) Emergency Procedures

(i) recovery from unusual attitudes

Never 'pull through' from inverted flight. The standard recovery technique to avoid excessive airspeed is to push the nose above the horizon to reduce speed below Va and roll back to erect flight.

Tail slides must be avoided in gliders not specifically cleared to undertake them. If one occurs accidentally or seems imminent, immediately brace all controls against the stops (The recommendation used to be to hold the stick rigidly central, but in practice this is impossible and almost invariably results in the controls slamming violently against the stops. This is not very good for them, and they are likely to fly off on their own after such treatment.)

(ii) drills to include the use of parachutes and aircraft abandonment are covered in Chapter 2 of the instructor manual.

A TEM assessment must be done before any aerobatic sortie.

TEM

Threats:	**Mitigation:**
Collision	Maintain thorough Lookout
Pupil reaction	Check if there has been any reaction to reduced G on previous flights
Reduced situational awareness	Build up progressively
Errors:	
Running out of height for appropriate circuit	Monitor height & position
Incorrect control inputs	Structured briefing and demonstration
Incorrect recovery from unusual attitude	Instructor takes control immediately
Trainee mishandles controls, with risk of over-stressing or tailslide	Brief and demonstrate thoroughly and guard controls (as far as is possible)

ADVICE TO INSTRUCTORS

Weather minima

Aerobatics need to be taught in smooth conditions so that the trainee can directly relate control inputs to the resulting motion of the glider. Turbulence can add significant and dangerous airframe loads to those already created by the manoeuvres. Ideally, aerobatics should be undertaken at the beginning and end of the day.

If there is extensive cloud, reference points can be difficult to see. These conditions may compromise good lookout during manoeuvres, so it is a good idea to avoid them.

Demonstrations

Always demonstrate a proposed manoeuvre or sequence before allowing the trainee to attempt it. This 'demonstration' is invaluable as it helps the trainee gain a feel for the figure(s) and gives them time to observe things which they might not notice when performing the figure(s) themselves.

Trainee Physical Responses

The trainee's reaction to aerobatics may be quite different to your own. Watch for signs of mental overload, adverse reaction to G etc. When things go wrong, the trainee's uncertainty may cause temporary paralysis of all useful mental functions. Be prepared to take over early if required. If the trainee shows signs of tiring, resort to simple figures or simply terminate the lesson.

Pre-flight HASSLL checks must be made immediately before each aerobatic session. These should be conducted on the ground and confirmed when airborne.

Height - Particular attention should be paid to the height level, as the height band of the proposed aerobatic session is likely to be much greater than that usually covered by the stalling and spinning exercises. Repeat the pre-agreed lower altitude limit so there is absolutely no ambiguity.

Airframe - Confirm that the glider is certified for the intended manoeuvres. Maximum and minimum airframe G loading should be noted and the accelerometer reset. Confirm the values for maximum manoeuvring (V_A) and never exceed (V_{NE}) speeds. Best practice is to point to these values on the instruments so at a glance, the trainee can quickly see if they are approaching these values in flight. If the undercarriage is retractable, check that it is up.

Straps - Make sure that all the straps are fitted into the buckle, and still tight.

Security - Check the cockpit to ensure that no loose articles can fly around and damage either the glider or the pilots. This check is best done before take-off so that likely 'flying objects' can be removed but repeat in the air.

Location - Ensure the glider is: not over a town or active airfield (without appropriate permission) or in controlled airspace. Confirm if the glider has been towed to the pre-agreed location by the tug pilot, and if not, either reposition or adapt the sortie plan accordingly.

Lookout - Execute two well banked clearing turns of 180° in each direction, to check that the airspace is clear of other traffic and will remain so long enough for the manoeuvre(s) to be completed.

Lookout needs to be especially vigilant. For example, looking for aircraft initially at a much lower altitude and still some distance away approaching the proposed aerobatics box. Aircraft directly below, etc.

PREFLIGHT BRIEFING

Before each flight, the exercises to be flown should be planned and briefed. The following items should also be covered:

- Target entry and exit speeds should be agreed. Ideally, the exit speed from one figure should approximate the entry speed for the next.
- Describe and discuss the method of flying each figure.
- Agree the proposed aerobatic box and the reference or aiming points to be used. Discuss the proposed interaction with local traffic and the local airfield requirements.
- The characteristics of the glider to be used e.g. how well does it spin. Identify any control weaknesses such as a small rudder or elevator etc.
- The glider's flight limitations.

Whilst not essential, it is advisable to draw an Aresti diagram for the proposed figures or sequence to be flown. The Aresti system is the international 'language' of aerobatics, using standard symbols to depict each figure and its direction of flight. If the trainee decides to move onto advanced or competition aerobatics, getting them familiar with the nomenclature and pictorial form of figures, will provide a useful foundation, making it easier for them to understand and brief sequences, communicate clearly with other pilots and judges, and ultimately prepare them for the standards and practices expected in advanced aerobatic training and competition. Information on Aresti is on the FAI website here:

https://www.fai.org/news/understanding-aresti-figures-aerobatic-competition

MANOEUVRE DEMONSTRATIONS

During these, trainee gains both a feel for the figures to be flown, and an appreciation of the key points to be looked for and controlled for the figures to be flown correctly.

These include:

- Aerobatic box axis aiming points both ahead and behind the glider, as well as on the horizon in the direction of the wing tips. A ground line feature such as a road, a railway or a runway provides the best axis reference of all.
- Load factors as measured on the installed G-meter, and as felt by the pilot.
- Airspeed indications on the ASI as well as the sound of the airflow.
- The relative height of wing tips above the horizon and the wing flex experienced during changing G loading.
- Attitude reference points for pitch control - ground, horizon, or cloud features.
- Wing tip reference triangle properly aligned to longitudinal axis of glider to provide indication of horizontal, vertical and 45° lines.
- Position of the controls.
- Yaw string and wing roll angle relative to horizon.

As with all instructing, the eventual aim is to enable the trainee to analyse and improve the accuracy of their own performance.

AEROBATIC MANOEUVRES

45° DOWN LINE

Identify both entry and exit speeds before commencing the procedure.

Commence from slow level flight with the level wings and no yaw:

- The entry speed should be low, typically 5kts above the stall speed. The trainee should look ahead and check that the wings remain level as they start to pitch down.
- The pitch down should be an even curve.
- Initially the trainee should look over the nose and use the horizon reference to keep the wings level.
- After approximately 30 degrees of pitch down, the trainee needs to look at the wingtip sighting device and watch it until the aircraft is at the correct angle. i.e. 45° down line
- Then stop the pitch and check if the angle is correct before looking ahead.
- Use a forward aiming point directly in front of the nose to maintain constant attitude control
- The longitudinal stability of the glider will try to pitch the aircraft up as the speed increases. So it is necessary to increase the forward pressure on the stick to keep the ground features in the same position
- As the airspeed indicator needle passes through the threshold speed, start a smooth but rapid pitch up to horizontal
- Pull out to horizontal flight at the correct (preselected) airspeed.

Common faults

- Dive too shallow. Ideally use a wing tip triangle and not the wing tip to judge.
- Dive shallows-out as speed builds.
- Incorrect pitch control as stick forces vary.
- Exit speed incorrect. Use a transition speed of, typically, 10kt less than the target speed - use pull out speed of 10kt less than target.
- Speed not maintained after exiting the down line due to a 'nose high' attitude.

Teaching Points

It is vital at this early stage of aerobatic training to ensure that the trainee looks at the sighting device and not merely glances in that direction. Therefore, the instructor should watch the trainee's head and prompt as vigorously as necessary. Once the aircraft is established in the dive at the correct angle, the trainee will look ahead. It is a common fault to see a diving line that becomes progressively shallower. The instructor can emphasise the use of a reference point to maintain the attitude. In this case, 'horizontal' is noticeably lower than for normal low speed flight to prevent the speed bleeding off between figures.

45° UP LINE

Identify both entry and exit speeds before starting the manoeuvre. Begin from level flight with the wings level and no yaw present.

- For training, the entry speed should be around 50kts above the stall speed. The target exit speed should be 5-10kts above the stalling speed
- The trainee should look ahead and check that the wings remain level as they start to pitch up
- The pitch up should be an even curve
- After approximately 30 degrees of pitch up, the trainee must look at the wingtip sighting device and watch it until the aircraft is at the correct angle. i.e. 45° up line
- The longitudinal stability of the glider will try to pitch the aircraft nose down as the speed decreases. So, it is necessary to keep back pressure on the stick to keep the ground features in the same position
- push over (at typically 15-20 kts above exit speed) to achieve horizontal flight a little above stalling speed.

Common faults

- Climb angle too shallow/too steep/not constant - use attitude reference e.g. clouds.
- Incorrect exit speed - use the ASI to judge correct push over speed.
- Pitch up to 45° not sharp enough - use the 3G load factor.
- Exit speed too slow - push over at VS + 20kt indicated airspeed.

Hazards Stall off the top – avoid this by pushing over further to regain speed.

WARNING! Most gliders are very susceptible to spinning in this condition.

Teaching Points

The ability to pitch up to the full 45 degrees is a key to later figures and trainees must establish the correct technique as a habit. The instructor should watch the trainees head to ensure that they look at the wing tip triangle: there is no other way of judging the angle. The figure must start with adequate speed to allow a definite line. The natural stability will tend to shallow the climbing line. However, the effect is not as noticeable because the climbing line is short. Some gliders are prone to stall if the pitch down is left too late.

INSIDE LOOP

An inside loop should be a horizontal line followed by a constant radius circle in the vertical plane with a horizontal exit line on the same heading.

Begin from horizontal flight at the correct entry speed 2.5 x Vs

- At entry, the wings must be level and the glider must be free from yaw.
- The pull-up should be progressive, typically with 3G load applied in first quarter.
- As you start to pull back, check the horizon and the yaw string to ensure that you are still correctly lined up with level wings.
- In the second quarter, as speed decays and the effectiveness of the elevator reduces, progressively ease back on the stick to maintain a constant radius.
- At the top of the loop the wings should be level and no yaw present. The load factor should remain positive (0.25G) the stick should be on rear stop.
- When you reach the inverted position at the top of the Loop relax the back pressure slightly, for a moment only, to reduce the rate of rotation and keep the radius constant with minimum speed. This will delay the dropping of the nose which will otherwise tend to fall too rapidly into the second half of the Loop, tightening the circle as it does so.
- Pressure should then be quickly but steadily re-applied and the stick moved slowly aft again to maintain the shape of the third quarter. (NB: the backpressure must not be relaxed too much at the top, or for more than a moment, otherwise speed will start to build rapidly in an inverted dive.)
- At the vertical up/ down position, the wing tips should be equidistant above the horizon.
- As you progress into the fourth quarter, speed will be building fast. Monitor speed closely and relax back-pressure steadily as the elevator becomes more effective in order (a) to achieve the target entry speed for the following figure and (b) to avoid an unnecessarily harsh pull-out and tightening of the Loop
- During the second half of the loop the elevator control must prevent initial over-tightening of the circle, whilst ensuring a horizontal exit at the same speed as the entry - or the selected target speed for the next figure.

Common faults

- Harsh pulling and/or pushing of the stick.
- Tightening of the circle during the second half of the figure.
- Entering the loop from a dive rather than from level flight.
- Incorrect lines and glider orientations throughout manoeuvre.
- Shape not circular.
- Segmented (angular sided).
- Failure to finish in level flight by pulling up into a climb to reduce speed.

Hazards

Insufficient speed can lead to an inverted stall before the top of the loop. Avoid this by pulling back fully and recovering from the dive – this will avoid a tailslide. Pulling back to hard over the top of the loop can stall the glider and induce a flick roll – if this happens, recover from the spin.

Teaching Points

If possible, the loop should be performed directly into the wind. That way the aircraft will be travelling against the wind at high speed at the entry and with the wind at low speed near the top.

Once the horizon has dropped below the nose, the trainee should look up as much as possible to catch an early view of the far horizon. Then as the far horizon approaches, slacken the loop by reducing the back pressure on the stick to 'float over the top.' That is an opportunity to check that the wings are still level.

Finally, the trainee must be confident in pitching without introducing unintended roll. In either case, the trainee must 'float the aircraft over the top' and wait for the nose to drop significantly before starting to tighten the pitch. If the trainee starts to pull as soon as the nose drops through the horizon, the third quarter of the loop will be very tight. Unless the trainee then has a slack fourth quarter, the loop will finish higher and slower than the entry. Once the trainee starts to pull in the middle of the third quarter, they need to progressively tighten the pitch as the speed increases. The maximum G will be just before the trainee stops the pitch at horizontal.

WINGOVER

A wingover (non-Aresti figure) is a smooth, climbing turn with wings vertical (no more) halfway round, then descending to exit on the reverse heading with wings level. i.e. essentially a more relaxed version of a Chandelle, using less than 45 degrees pitch up and less than 45 degrees of roll.

Entry and exit speeds should be 80kts or more.

Begin from horizontal flight at the correct entry speed.

- The aircraft is pitched up-to a maximum 45-degree line. Stop the pitch.
- Then roll to a maximum of 45 degrees of bank whilst on that line.
- Centralise the ailerons to stop the bank increasing. Pull round the turn by maintaining back stick pressure.
- The aircraft will perform a 180 degree turn on that inclined plane until it is diving at up-to 45 degrees in the opposite direction to the entry.
- Look for the exit direction. This will be parallel to the reference line and pitched 45 degrees down. Keep pulling until the nose is on the exit line.
- Then apply a good firm forward movement on the stick to stop the nose on the exit line. After a slight hesitation, roll hard until the wings are level in a 45-degree dive.
- Wait for the speed to build whilst preventing the nose rising.
- At 10kts short of the entry speed for the next figure, start to pull into straight and level flight.

If performed well, at the highest point the fuselage will be horizontal, pointing 90 degrees to the entry direction with the wings vertical. The aircraft will still have a fair amount of speed, so the wings are generating enough lift to keep pulling round the turn.

Common Faults

- Too slow an entry will result in the aircraft falling out of the turn.
- Not pitching up sufficiently. If the aircraft is then under-rolled, the pull will lift the nose high until all speed is lost and the aircraft falls out.
- After rolling, it is common to keep on some roll as the aircraft is turned. This results in the wings being over-vertical at the top and an exit off heading. The instructor should emphasise the need to fully stop the roll before pulling round the turn.

Hazards

The main risk is entering the manoeuvre too slowly and running out of energy part-way through, which can lead to a wing-drop or stall. Over-rolling at the top can also result in the wings going past vertical into inverted flight. Excessive or mistimed elevator input while slow can provoke an incipient spin. Height loss is modest when flown correctly, but poor coordination can increase it significantly, reducing margins for recovery.

Teaching Points

At first sight, this seems like a good figure to introduce early in training. It is reasonably gentle, it does not involve extreme attitudes, the height loss is modest and so you can do several in a row. Unfortunately, it is quite a difficult figure to get right, as it involves coordinating many different movements of the controls. Therefore, it is best postponed until the trainee is good at the pitching manoeuvres.

This figure benefits from a ground rehearsal of the control and head movements. Without a ground rehearsal, many trainees will hesitate too long between the various stages and so run out of speed.

LAZY EIGHT

A LAZY EIGHT is non-Aresti figure and consists of one 270-degree turn followed immediately by a second 270-degree turn in the opposite direction, both flown at a constant speed and 45-degree angle of bank.

Before starting pick a clear linear feature to use as a reference line. Start from level flight at an appropriate entry speed.

- Roll on 45 degrees of bank whilst maintaining heading. Stop the roll.
- Pull round the turn whilst ensuring the pitch attitude remains appropriate to maintain the selected speed. Note: trainees will tend to 'pull' the nose above the horizon as they are used to the normal gliding attitude.
- Once perpendicular to your reference feature, immediately roll to 45 degrees of bank in the opposite direction whilst maintaining the heading. Stop the roll.
- Pull round the turn whilst ensuring the pitch attitude remains constant. Once the second 270 turn is complete and you are flying parallel to your reference feature, roll wings level whilst maintaining the heading.

Common Faults

- Shallow angle of bank / pulling too hard resulting in speed loss through the turn.
- Failure to anticipate the roll out of turns.
- Rolling into/out of the turns without maintaining a constant heading.

Hazards

The Lazy Eight involves steep angles of bank coupled with continuous turning, so the most common hazard is loss of speed awareness. Pulling too hard during either turn can bring the aircraft close to the stall, particularly if bank angles are shallow and back pressure is increased excessively. If bank angles are too steep, trainees may find themselves entering a spiral dive, with speed and G loadings increasing quickly.

Teaching Points

Compasses in gliders suffer from significant turning and acceleration errors rendering them unusable for aerobatics. It is therefore necessary to pick a clear reference feature for this manoeuvre such as a runway or railway If starting parallel to the reference feature, then the first 270 turn will result in flying perpendicular to the feature. The second turn in the opposite direction brings the glider's track back parallel to it.

This is likely to be the first time the trainee has been asked to roll the glider, whilst maintaining a heading. This skill is essential to fly aerobatic figures accurately, particularly during competitions. During the rolling phases of the manoeuvre, the heading can be maintained by utilising adverse yaw; by using slightly less rudder than is required for a co-ordinated turn, the nose will stay on a particular heading until the roll is complete, at which point the trainee should resume a normal co-ordinated turn.

The transition from turning in one direction in the first half, to the other direction in the second half, involves a roll through 90 degrees but with practice, the heading can be maintained using the same method.

SPIN AND EXIT ON A HEADING

Entry from horizontal flight at VS plus 2kt with no discernible pitch-up:

- Exit should be exactly on desired heading e.g., one turn, one half turn etc.
- Exit dive should be momentarily vertical followed by transition to horizontal flight.
- The recovery 'lead' angle must be clearly defined with regard to useable ground reference features e.g., roads, railway lines, runways etc.

Common faults

- Entry not clean. Any amount of initial pitch up should be avoided.
- Spin not maintained.
- Spiral dive develops.
- Exit dive not on heading, and/or yawed.
- Transition from vertical to horizontal flight too gentle

Hazards

Incorrect entry may result in a spiral dive rather than a fully developed spin, creating high speeds and load factors. Over-rotation or late recovery can cause the aircraft to overshoot the intended heading and lose more height than planned. Mishandling the recovery can delay recovery or flatten the spin. As spins are often disorientating, the trainee may experience sensory illusions that could delay or confuse recovery if not well-briefed.

Teaching Points

Trainees should already be familiar with spins and spin recovery. Spins and slow flight are a confidence manoeuvres that trainees must revisit before embarking on their aerobatic training. Aerobatic spins require the pilot to accurately enter a spin with no noticeable pitch up and exit on a heading. The direction of the spin does not matter. During competitions, pilots are expected to exit a spin on to a momentary vertical downline, but that does not need to be taught at the basic level.

The glider should be slowed to just above the stall speed (Vs + 2kts) with the wings level. The spin is entered using full pro-spin rudder. Once the nose begins to drop, full up elevator should be used, with continued pro-spin rudder to maintain the spin. The trainee must also anticipate the desired exit heading, and 'recover' from the spin accordingly. For a one turn spin, beginning the recovery action somewhere between ¼ and 1/8th of a turn before the desired heading usually works well, but is depending on the type of glider and how vigorously the trainee applies the recovery action.

Once the spin has stopped, recover to a horizonal, wings-level attitude.

DE-BRIEFING

A structured de-brief is essential to consolidate learning. The discussion should be supportive, factual, and encourage self-analysis. Key points to cover include:

- Pilot self-assessment: Invite the trainee to describe how they felt, what went well, and where they struggled.
- Achievement of objectives: Review whether the planned lesson aims were met and highlight specific progress.
- Accuracy and safety: Discuss adherence to altitude limits,, speeds, lookout, recovery margins, and safe handling practices.
- Recognition of sensations: Reinforce what the trainee saw, felt, and heard during manoeuvres, linking these perceptions to correct control responses.
- Error analysis: Identify any common errors (e.g. control coordination, over-rotation, height loss) and explain how to avoid them next time.
- Confidence building: Emphasise strengths and reassure the trainee that errors are a normal part of learning aerobatics.
- Preparation for next lesson: Set clear, achievable aims for the following flight so the trainee remains motivated and focused.

The aim is to ensure the trainee leaves the flight with a clear understanding of their progress, specific areas to work on, and confidence in their ability to continue developing safely.

COMMON DIFFICULTIES

Trainees encounter a range of recurring difficulties when learning aerobatics. Most of these are not signs of poor ability, but simply reflect the unfamiliarity of the forces, sensations and unusual attitudes experienced, and the increased workload that brings. Instructors should anticipate these issues and be ready with strategies to address them.

Loss of height and speed awareness due to increased workload is a common problem early in aerobatic training. In the focus of maintaining attitude and symmetry, trainees may delay recoveries or allow figures to over-run the agreed speeds. Instructors should reinforce the discipline of constant cross-checks, use of reference points, and terminating figures early if needed.

Incomplete lookout and orientation, particularly when heads are kept rigidly forward rather than moving to maintain full situational awareness. Trainees often struggle to look in the right place at the right time: over the nose to judge wings level, or at the wingtip sighting device to establish correct 45° or vertical lines. Looking in the wrong place leads to poorly aligned figures and inaccurate lines.

Turning the head while under G can create disorientating proprioceptive and vestibular sensations, which can unsettle the trainee and reduce their confidence. Instructors should brief these effects in advance and stress the importance of deliberate, well-timed head movements linked to key references.

BASIC AEROBATICS -The Flight Envelope

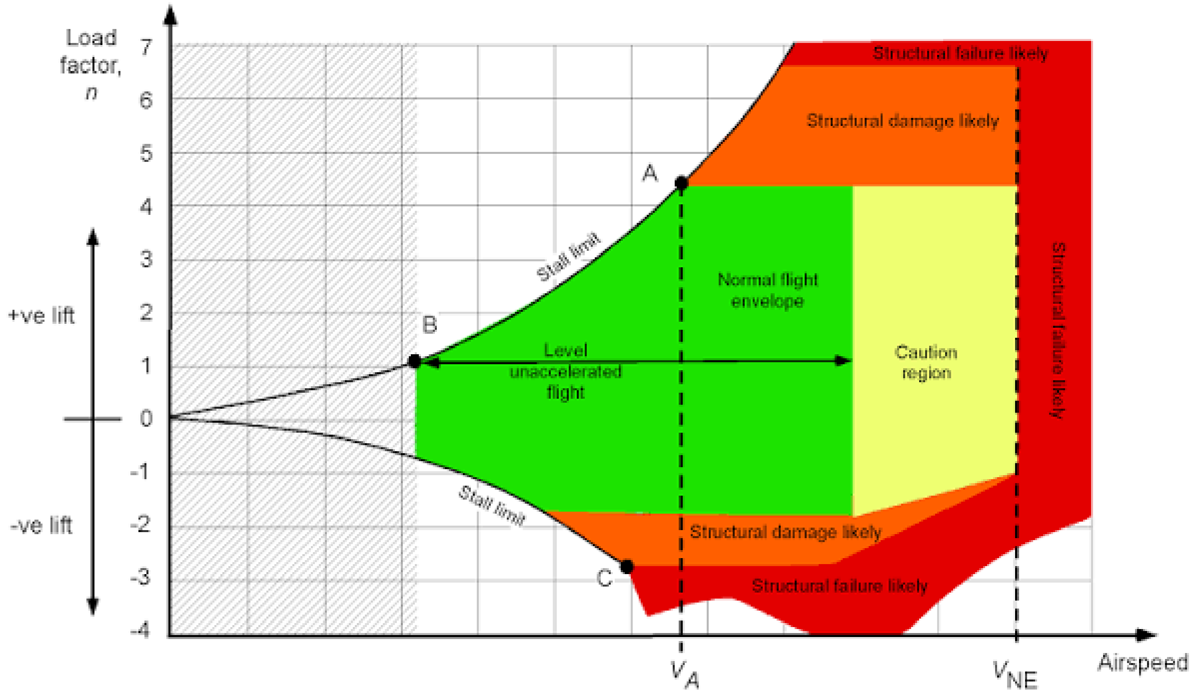
The flight envelope outlines the operating limits for aircraft. The key difference from a powered aircraft is that a glider lacks an engine, so its performance is driven by gravity and atmospheric lift rather than thrust. The flight envelope for a specific glider model is represented on a chart plotting airspeed against the load factor.

Load Factor is the effective weight of the aircraft that takes into account the actual weight and other acceleration factors and dividing it by the actual weight. Greater than zero is often referred to as positive G and less than zero is the area that applies to negative G manoeuvres.

The upper curved line is the stall speed of the glider at various loads – i.e. stall speed increases at higher g loadings.

Gliders are designed to withstand and operate satisfactorily up to their flight limit loads without any permanent structural deformation. Most gliders are limited to 5 g. The ultimate strength is required to be at least 1.5 times greater, with an ability to resist these loads for at least three seconds before failure occurs. Gliders designed as specialist aerobatic aircraft have a higher flight limit load up to 7G.

Fig 1 Simplified flight envelope



Low speed limits: are defined by the stall speeds.

High-speed limits:

Vne is the never exceed speed under any conditions. (Marked by a red line on the ASI) Vne is determined by the manufacturer during the certification process to ensure structural integrity and includes a safety margin for potential errors. Exceeding Vne can lead to catastrophic failure due to issues like uncontrollable flutter or parts breaking off the aircraft. It is normally set at 0.9 x Vd.

Vd is a theoretically calculated speed at which the aircraft would be safe to fly in completely smooth air. The aircraft will never have been flown at this speed.

Va is the manoeuvring speed. This is the maximum speed at which you can have full deflection of more than one control surface (nominally the elevator) without risking structural damage due to high loads. Wings are designed to be strong in tension but not in torsion. As speed increases Centre of Pressure, moves backwards hence wing twisting and flutter.

The torsion caused by the CoP moving backwards effectively reduces the strength of wing as speed increases. The use of ailerons makes it worse, as does the use of airbrakes. Therefore, max g allowed decreases as speed is increased

Vb (or Vra) Maximum rough air speed. The highest speed recommended for flight in turbulent or gusty conditions to avoid structural stress. It is calculated based on the maximum load factor which is imposed upon the airframe in response to a standard knife edged gust of 15 m/s velocity in the vertical direction. Often **Va** and **Vb** are often the same speed, but **Va** may be lower than **Vb** for some aircraft.

Gust envelope: Gust lines at 15m/sec and 7.5 m/sec can be superimposed on the flight envelope to display the gust envelope. i.e. a representation of how upward and downward gusts of varying intensity affect the aircraft's load factor at different speeds. This includes specific speeds for strong and weak gusts. (see fig 2.)

Factors affecting the flight envelope

Significant additional forces can be imposed on the airframe by the following:

- **Use of rudder to generate yaw forces**

  Simultaneous use of full rudder and full elevator is normally confined to flick manoeuvres. Where these are authorised for the glider type, the Flight Manual will specify a limiting entry speed. That value should be treated as the maximum safe speed for applying rapid, full deflections of both controls together. In many training gliders this limit is significantly lower than the published manoeuvring speed — for example, around 55 knots on an aircraft with a Va of 90 knots.

Note: flick manoeuvres cause huge twisting loads and should not be performed unless specified in the flight manual that they are permitted.

- **Use of aileron to generate roll forces**

  When roll control is applied, an additional load limitation applies to the aircraft. This 'rolling G limit' is lower than the maximum structural load factor since the wings must resist both the normal bending forces and the extra twisting forces generated by aileron deflection. The Flight Manual often shows this as a separate rolling limit line on the manoeuvring envelope diagram.

In practice, most rolling manoeuvres are flown at light to moderate g, so operating within this reduced envelope is not usually restrictive — provided full aileron deflection is avoided above manoeuvring speed (Va). More caution is needed in figures that combine higher airspeeds with elevator and aileron inputs together, where the combined stresses can be significant. Typical examples include Cubans, cloverleafs, and barrel rolls.

- **Use of airbrakes**

  The use of the airbrakes causes a significant increase in the loads applied to the glider, requires limitation of the Flight Envelope in a similar way to the ailerons. The reasons are:

  (a) the airbrakes destroy lift over a fairly large inboard section of the wing causing the spanwise wing lift distribution to move outboard. This substantially increases wing bending moments.

  (b) the airbrakes also generate drag loads on the wing, a proportion of which become an additional load in the pitch plane direction.

Note: It is nearly always better to slow a glider by 'pulling g' rather than by opening the airbrakes

This limitation is displayed as an airbrake opening limit on fig 2 below.

Figure 2